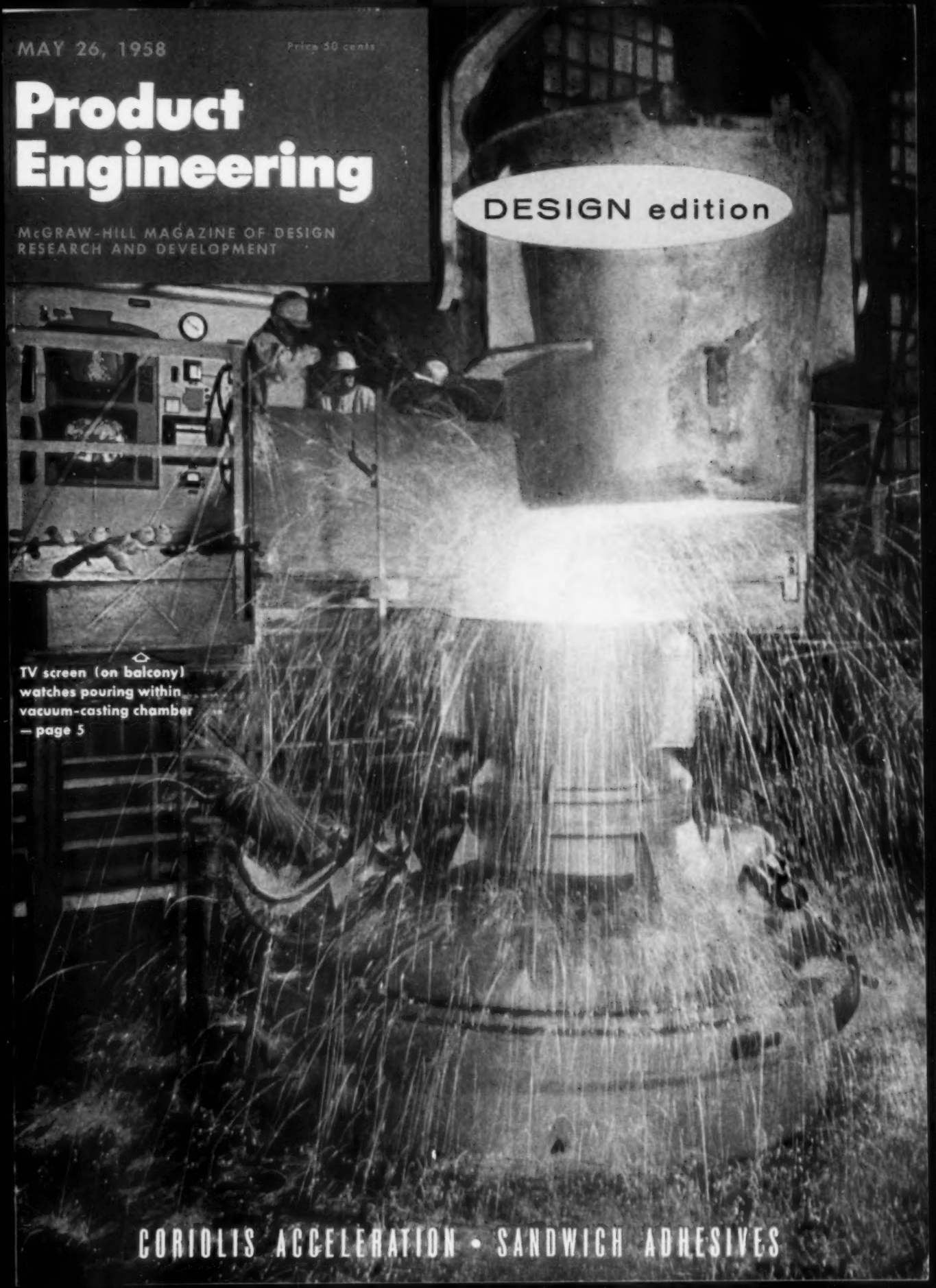
MAY 26, 1958 Price 50 cents

Product Engineering

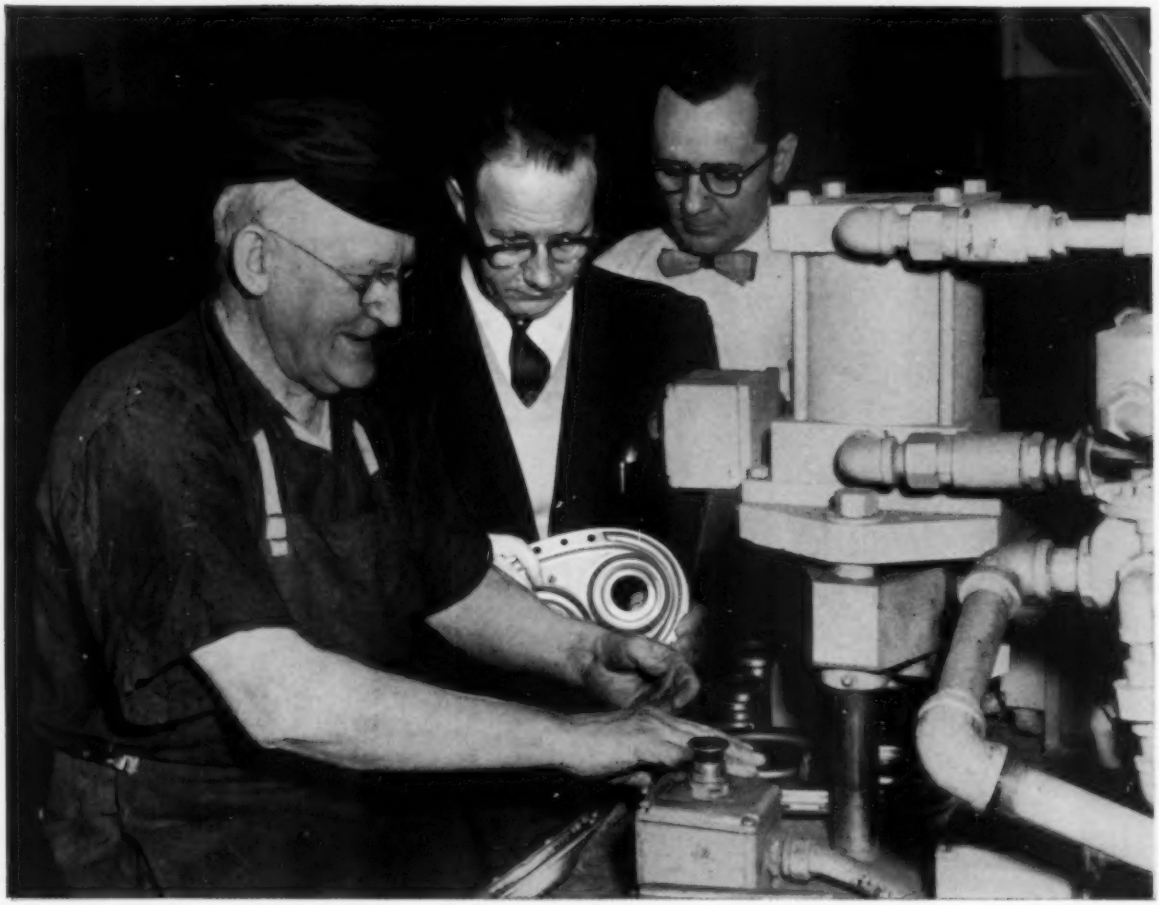
McGRAW-HILL MAGAZINE OF DESIGN
RESEARCH AND DEVELOPMENT

DESIGN edition



TV screen (on balcony) watches pouring within vacuum-casting chamber — page 5

CORIOLIS ACCELERATION • SANDWICH ADHESIVES



You may have met the man in the middle–

He is one of our C/R Sales Engineers. He, or one of his associates, may have been in your plant many times. Here, he's shown helping to check the installation of a C/R oil seal on a Detroit automotive assembly line—*after the seal design has been approved for production.* He wants to make absolutely certain this seal is installed correctly to assure maximum performance and service.

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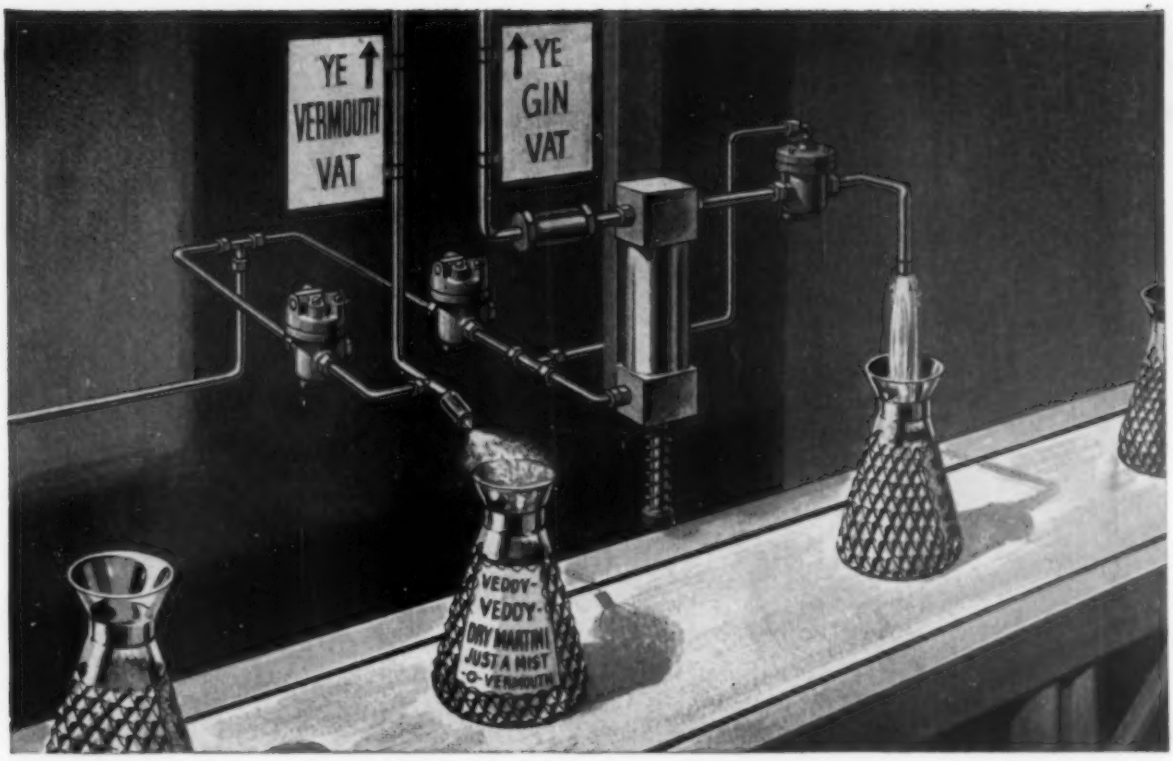


What? Air Automates the Extra, Extra-Dry Martini!

The ready mixed Martini may never come to this but . . .

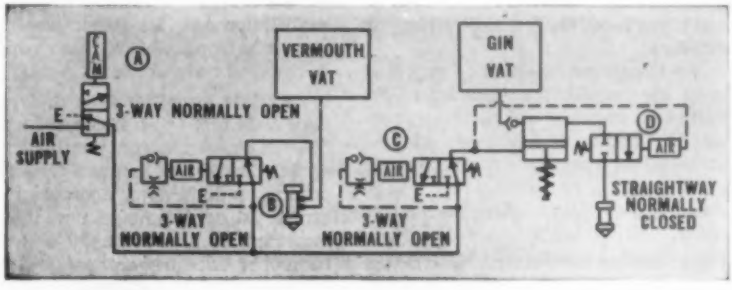
"Don't bruise the Vermouth!" Maybe you subscribe to the idea of only a fog of Vermouth or maybe you like yours four-to-one. But, if it came to bottling this vogue-ish mixture, the circuit here could certainly do it. Meanwhile it gives us a fanciful way to show you how you can easily create an all air circuit that does a continuous sequence of timed operations by using valves that can be both operated and sequenced by air. Every time the conveyor stops, it triggers the circuit.

Triggering one operation with another and timing the operating periods—all with air—may save the day for you.

The same air involved in the main operation can also pilot these valves. What's more these valves can be preset to wait out a time delay before operating, or operate for a self-measured time. Using them you can create unlimited all-air automation systems which could just turn the trick where you wish to avoid electricity, or want to stick with just one power medium.

SEQUENCE OF OPERATION

1. Conveyor indexes, opening cam valve (A). This introduces air to valves (B) and (C) which begin timing out. Vermouth is atomized by Vermouth nozzle, cylinder expels a measured amount of gin through master valve (D) which has been opened by air from the outlet of valve (C).
2. Valves (B) and (C) time out and close, stopping liquid flow.
3. Conveyor indexes again.



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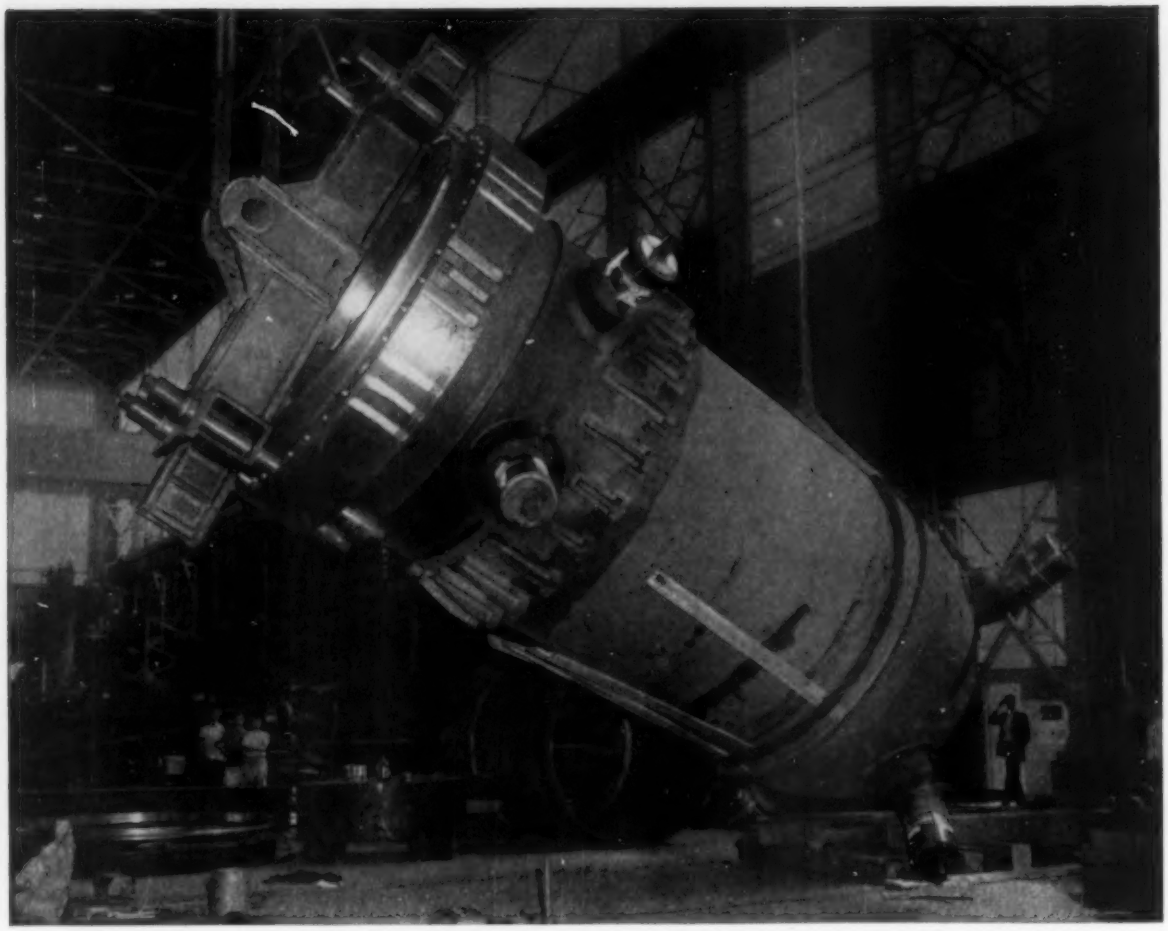

Bringing home the atom. Electricity will soon flow from the first full-scale nuclear power plant in America. This 235-ton reactor vessel was designed and built with alloy steels and nickel alloys by Combustion Engineering, Inc. It will supply power for the 60,000 kilowatt Shippingport plant designed by Westinghouse Electric Corporation.

In Shippingport atomic reactor...

Inconel "X" will keep "hungry water" on a starvation diet

"Hungry water" is the apt name for high-purity coolant that whirls through the super-hot core of a nuclear reactor.

It tries to feed on anything it touches!

Its immoderate appetite explains why the reactor for America's first full-scale commercial nuclear power plant had to be designed and constructed as it was—*with core mount springs made of Inconel "X"* age-hardenable nickel-chromium-iron alloy.*

Other spring materials would relax long before operating temperatures hit their peak above 500°F. Or they might fail completely from what is called "stress-corrosion cracking", or embrittlement. In either event, it would be impossible to make repairs because of radioactivity.

It was this consideration that practically dictated the choice of Inconel "X" alloy. An exceptionally tough spring material, Inconel "X" alloy stands up to heat . . . corrosion . . . stress. In a lifetime of use, it's not expected to give "hungry water" a morsel of encouragement!

Have you a metal problem? One involving corrosion, high or low temperatures, abrasion, fatigue? Some helpful answers are in our "Standard Alloys for Special Problems". Ask for a copy. If your problem involves springs, as this one did, ask us for *Technical Bulletin T-35.* Contains complete design information on Inco Nickel alloys for helical springs; it'll prove a valuable addition to your engineering reference files.

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Product Engineering

THE McGRAW-HILL MAGAZINE OF DESIGN, RESEARCH AND DEVELOPMENT

MAY 26, 1958 Vol. 29, No. 21

Sandwich Panel Adhesives * 56... R. K. Humke, Minnesota Mining & Mfg. Co.
Here are the 14 most widely specified adhesives—with a comparison table for guidance. Author's previous articles in 3-part series were on cores and facing materials.

Equations Predict Assembly Fits 61... W. Hanka, Military Aircraft Factory, Cordoba, Argentina
Tight tolerances aren't always necessary—sometimes you can gamble on wider ones that save money and often work satisfactorily. But before gambling on misfits, know the odds.

Pressure Switches 64... E. E. Opel, National Automatic Tool Co., Inc.
Usually these devices are picked to check pressure. Article tells how they can also be put to work like a limit switch—to indicate completed movement.

Design Features in New Products 66... Lift truck needs no mast; underwater eye has remote controls; welded stampings form universal mounting plates; coolant is key to rapid boring.

Vacuum Steel Grows Up 70... J. H. Stoll, Bethlehem Steel Co.
Now high-strength forgings are possible in large sizes. Vacuum pouring insures against flakes, reduces nonmetallic content, gives better ductility.

STAFF REPORT

Coriolis Acceleration *72... Nicholas Chironis, Associate Editor
Here is a force to be reckoned with in explaining many phenomena. Article describes it in simple equations and shows how the force affects components such as planetary gears.

Memory Valve for Logic Circuits 76... R. J. Cameron, Ross Operating Valve Co.
Why limit the logic function called MEMORY to electrical circuitry? It's also applicable when air is to be valved in automatic sequences.

DESIGN FILE

10 Ways to Employ Screw Mechanisms 80... Federico Strasser, Mankewitz & Strasser, Ltd., Santiago, Chile
Survey covers usefulness of various types.

Geneva Wheels 83... Douglas C. Greenwood, Assistant Editor
Design diagrams and formulas for this helpful mechanism.

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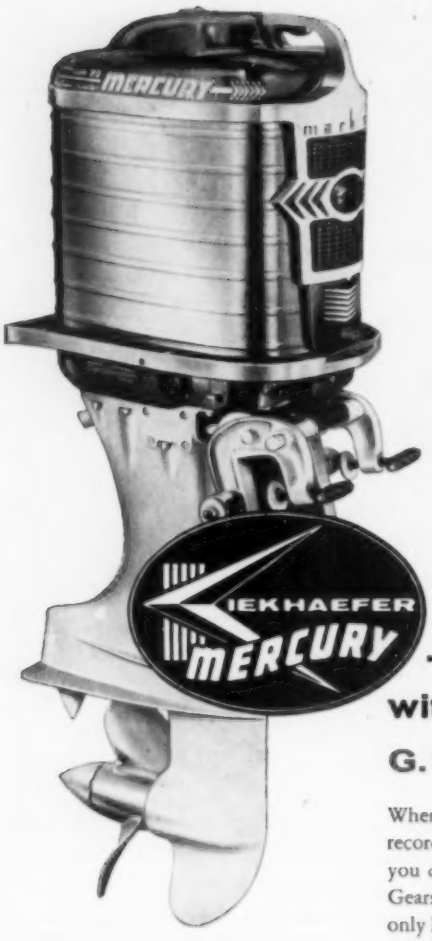

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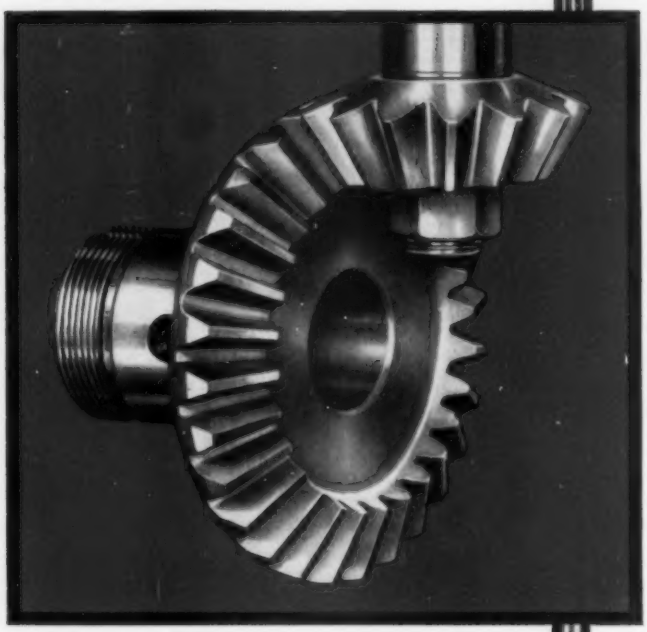

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When you make the kind of outboards that set new world's endurance records (as Kiekhaefer Corporation's famous "Mercurys" have done), you don't settle for anything but the best when it comes to specifying Gears and Pinions. And "the best" means G.S., in the experience of not only Kiekhaefer but of leading manufacturers in all divisions of industry.

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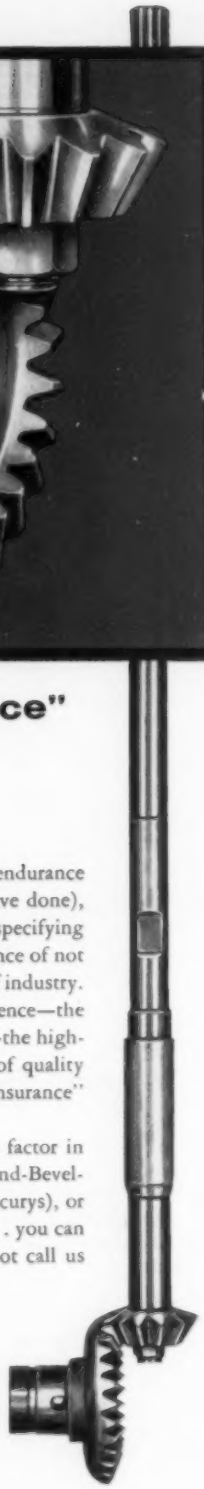

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Interesting to Note . . .

Temperamental Woman

During the early days of steel making, temperamental blast furnaces were a problem. They wouldn't function properly. They would produce impure steel; or cough fire and smoke, then burn out. A result of this erratic behavior was the custom of naming individual blast furnaces after wives and sweethearts. At one time there were more than 100 furnaces bearing feminine names—nine Graces, five Fannies and four each of Emmas, Elizabeths, Rebeccas, and Lucys.

That tradition is fading and now the big furnaces are coldly referred to as Number One Furnace or Number Two. In 1952, however, Benjamin Fairless of US Steel went back to tradition. Christening a new furnace at the Fairless Works, he named it after his granddaughter—the Nancy furnace.

Our cover pictures a further step in the steel process, vacuum pouring. This process is not new: one patent goes back to 1883. Yet vacuum pouring and casting of steel has grown so that now up to 250 tons can be poured at once. The article on page 70 gives details of the vacuum casting process.

A Heap of Parts

Around the turn of the century, engineering giants had established themselves in Detroit's new industry—automobiles. Henry Ford had won his patent suit with Selden (*PE*—Feb. '57, p. 7). R. E. Olds, Howard Coffin (Hudson), and James Packard had set out to design and manufacture a better product than Ford's. And in 1901, the 51-year-old Henry M. Leland took over the Detroit Automobile Co. and started making the Cadillac. With Leland in the driver's seat, the company designed the electric starter, the V-type engine and thermostatic control of engine temperature. More important, Leland was a perfectionist—he demanded accuracy. For example, a man selling roller bearings had an interview with him. Leland measured the salesman's merchandise and found the bearings didn't all match. Dismissing the salesman, he said, "Cadillacs, young man are made to run, not just sell." This good advice is still worth heeding.

Leland dramatically displayed his demands at a demonstration in England in 1906. Three Cadillacs were shipped to a shed at Brooklands track. The various parts were interchanged and dumped in a

(Continued on page 7)

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WHERE	WHY	HOW
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Pressure testing in automotive production	Oil gets contaminated by scale in castings (not critical to dirt) reduced maintenance	Sealing surfaces in constant, intimate contact, dirt can't lock valving members – saves coil burn-out
Hydraulic work feed apparatus	(Leakproof) . . . as versus spool valves which cause overdemand on hydraulic system	Positive shut off of internal port to port leakage and of course, no external leakage
Machine tool chucking & clamping	Maintaining safe holding pressure (leakproof)	Saving auxiliary equipment such as pilot operated check valves
Automatic door openers	Quick action (high flow capacity)	No spools or poppets obstructing full, round flow passages
Solenoid controlled hydraulic system on machine you build	Better performance Lower manufacturing costs Reduce service problems	Shear-Seal valves have full flow, are leakproof, not sensitive to dirt Low priced, less auxiliary equipment and labor cost. Valves don't stick, saving coil burn-out; stay leakproof indefinitely, seals are wear compensating

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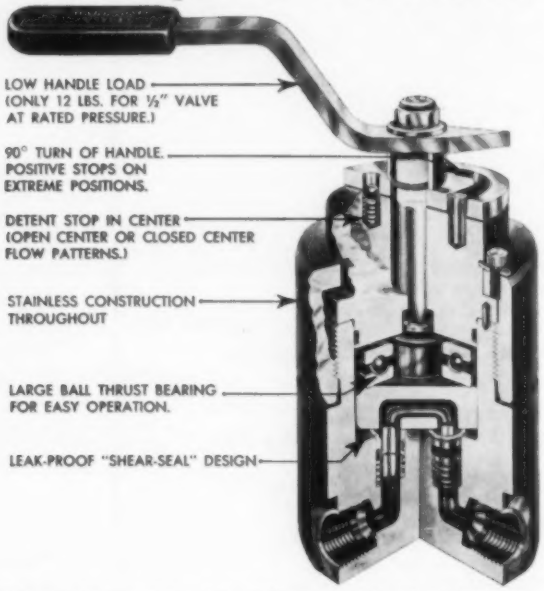
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No port to port leakage occurs in the detented positions because of the exclusive "Shear-Seal" design.

Long, maintenance-free service is assured because the optically flat metal to metal sealing surfaces of the sealing rings and mating rotor faces are protected by staying in constant intimate contact; flow is always through the center of the "Shear-Seal", never across sealing surfaces (as in conventional valve design). Sealing qualities actually improve as the self aligning "Shear-Seals" lap themselves to a more perfect fit with each valve operation.

Of course, there is no external shaft leakage, because the pressure is confined to the flow passages.

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heap before a curious crowd. Then, mechanics assembled the cars with no tools other than wrench, hammer, screw driver and pliers. This first English demonstration of motor car standardization created a profound impression. Interchangeability of parts is now standard, yet precision fits do not necessarily mean precision machining operations. The article on page 61 shows how wide tolerances can give satisfactory fits. As for that roller bearing salesman, his name was Alfred P. Sloan, Jr., who later became president of General Motors.

When Does a Sandwich Become a Meal?

The word sandwich has taken on many different meanings. Not only does the term apply to easy eating *(PE—Apr. 28, p. 7)* but the name has been borrowed by designers as a type of structural material. Sandwich adhesives, for example, are discussed on page 56. Recently the term has been the source of an international hassle among airline companies. According to feeding rules set up by the International Air Transport Association, passengers on low-cost trans-Atlantic flights may only be served sandwiches.

Last month, Pan American World Airways alleged that four European airlines are violating this rule by serving what amounts to meals—on bread. Scandinavian Airlines took the brunt of Pan Am's attack but defends itself: "Sandwiches simply are food on a slice of bread, for example, three slices of roast beef, roasted onions, sliced pickle, lettuce heart and carrots—with a slice of bread" or "five slices of liver pate, fried bacon, mushrooms, sliced tomato—with a slice of bread."

"Those aren't sandwiches," says Pan American, "they're meals."

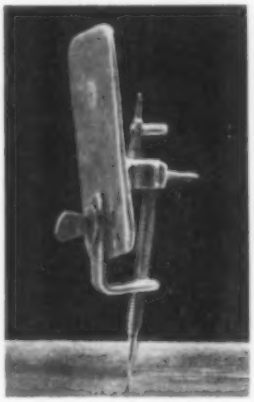
Swissair, K. L. M. and Air France also serve smorgasbord on bread but claim to be within their rights. One spokesman for Swissair sums up the problem, "Every man is entitled to his concept of a sandwich, and we have ours."

It's a Good Story

Ben Franklin will be remembered by every schoolchild because of his dramatic "key and kite" experiment *(PE—April '57, p. 7)*. Newton may not have first pondered gravity after being hit on the head by an apple, but it makes a good story. There is also a story told about Galileo. In order to prove his theory of "falling bodies" it's said that he took a 10-lb and a ½-lb ball atop the tower of Pisa and let them fall simultaneously. There is nothing to substantiate this story of showmanship, but Galileo will long be associated with falling balls and that leaning tower of Pisa.

Galileo also was associated with vacuum studies. He tried for many years to achieve the perfect vacuum by filling a cylinder with water, then removing a piston. He died before he was able to accomplish the desired results but his pupil and friend Evangelista Torricelli did what Galileo couldn't. After sealing one end of a 3-ft tube, he filled it with mercury, and stood the open end in a dish of mercury. The mercury in the tube fell until it was about 30 in. above the surface of the mercury in the bowl. Torricelli not only produced the vacuum Galileo couldn't, but invented an instrument for *recording* pressure, the barometer. The instrument for *controlling* pressure, the pressure switch, is discussed on page 64. Few remember Torricelli, yet showman Galileo will forever live in science books.

Letters from a Dutchman



After completing his job, sweeping the floors at City Hall, young Anthony would return home to help run a dry-goods store. This done, he would retire to his room and experiment with lenses. Little was known about lens-making in 1650 but this 18-year-old boy in Delft, Holland, was afflicted with the disease of the scientist, curiosity. Anthony spent endless hours grinding and polishing glass, then with great care assembled his lenses on homemade oblongs of silver or copper. Upon peeking through his lens, the boy entered a world never before visited. He looked at hairs and flies; at bones and wood—all many times enlarged. Neighbors were invited to share the world of the microbe but they just laughed at what they saw, and condemned the young man as an idiot. How different today! (See p. 66)

One day, biologist Regnier de Graff took a look at a fly's eye through the boy's lens and immediately wrote the Royal Society in London of his experience. The Society contacted the Dutchman and for 75 years was treated to the most amazing series of letters. The janitor-shopkeeper wrote of his every experience behind the "miscroscope." Hundreds of notes discussing town gossip, homely philosophy and a world in miniature enriched the lives of such Society members as Robert Boyle and Isaac Newton. For the first time water was analyzed and said to contain "wretched beasties"; blood was said to be made of cells; heat was claimed to be destructive to the invisible creatures. The Royal Society learned and became enlightened by the letters from a Dutchman named Anthony Leeuwenhoek,—Benedict A. Leerburger Jr.

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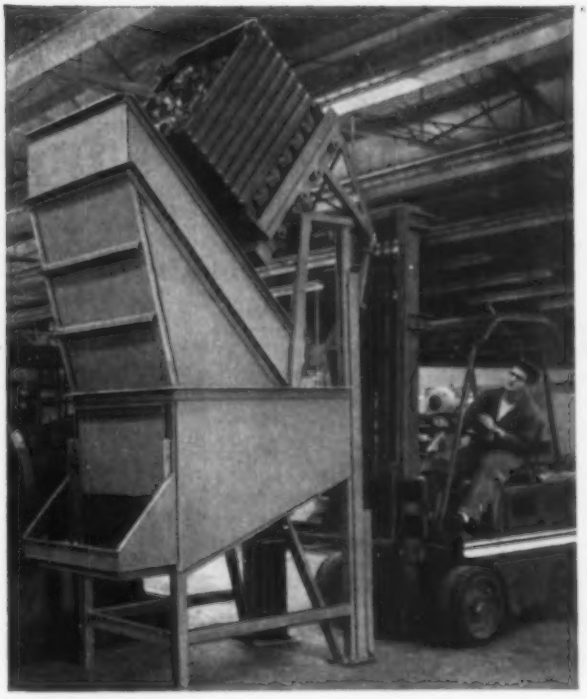
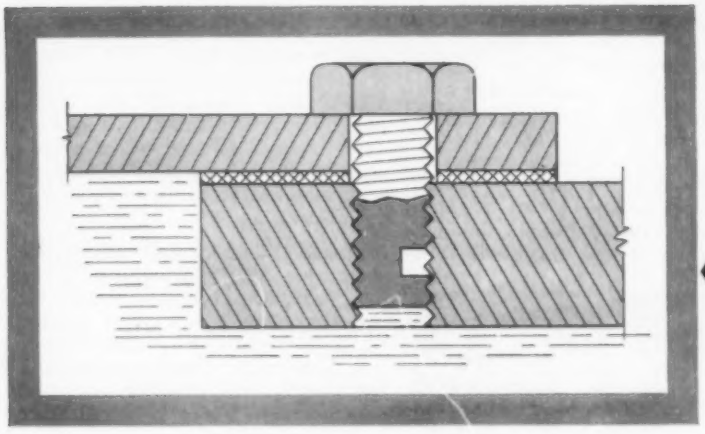
If you mass produce multi-diameter machine shafts it will pay you to investigate the savings potential of Republic Die-Form. Your nearest Republic office can provide details. Or write for Die-Form Folder ADV-746.

REPUBLIC ELECTRO PAINTLOK ASSURES TROUBLE-FREE PERFORMANCE for this unique, fully-automatic trap produced by the Self Sett Mouse Trap Company, Cleveland, Ohio. Electro Paintlok® proved superior to all other sheet products tested by Self Sett in meeting combined requirements for economy, formability, paint adherence, and corrosion resistance. Thanks to Electro Paintlok, trap life is expected to exceed 20 years with normal care. Republic Electro Paintlok offers all these advantages for *your* product. Send for facts.





REPUBLIC BOX AND SKID UNITS PERFORM FOUR JOBS, CUT HANDLING COSTS 10% at Dresser Industries' new pipe fittings plant at Wellsboro, Pennsylvania. Four functions are: (1) delivery of semi-finished parts to production stations; (2) feeding parts to machines via special hoppers; (3) receiving finished parts; (4) storage for shipment. In addition to immediate cost savings of 10%, Republic's rugged, corrugated steel construction assures years of minimum maintenance service. Send for data on Republic Materials Handling Equipment.

LIQUID SEALING PERFORMANCE is an added benefit of Republic Self-Locking Nylok® Bolts. As shown here, the nylon pellet in compression tends to expand and interrupt space between non-loadbearing surfaces of mating threads when bolt is wrenched tight. Fluid escape along helical thread path is blocked. Nylon pellet resists aging, moisture, and ordinary solvents to provide a long-lasting seal. Send coupon for information on all the benefits of Republic Nylok Fasteners.

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World's Widest Range of Standard Steels and Steel Products

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☐ Please send Republic Die-Form Folder ADV-746
Please send more information on:
☐ Materials Handling Equipment
☐ Nylok Fasteners ☐ Electro Paintlok Sheets

Name_____ Title_____

Company_____

Address_____

City_____ Zone____ State_____

Excellent Formability of Magnesium Inspires Simplified Designs

Deep drawn components, for example, replace multipart assemblies

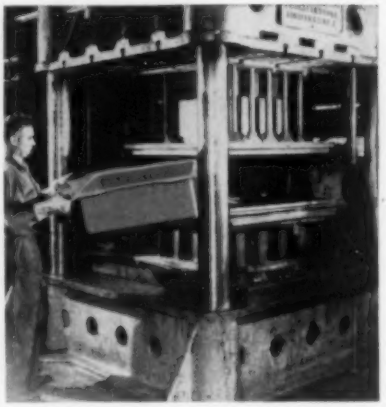
IN forming magnesium alloys, there's often more than one way to do the job. Matter of fact, the excellent shop characteristics of this remarkable metal permit it to be formed by almost every forming method known. The use of magnesium makes it possible to simplify complex designs that otherwise would require several separate parts and numerous production operations. Its high strength-to-weight ratio permits a choice of lighter design without loss of strength, or stronger design without weight penalty. Magnesium's hexagonal crystalline structure means excellent workability at elevated temperatures which offers the following advantages:

1. Deeper single draws than with other metals.
2. Reduced tooling costs.
3. Minimized springback.
4. Less wrinkling.
5. Better tolerance control by temperature adjustment.

These considerations, added to the fact that magnesium is the metal that's easiest to machine and fabricate, mean substantial cost savings in design and production.

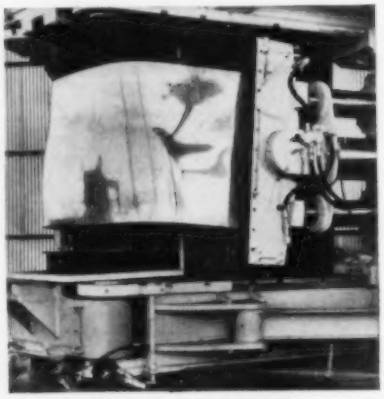
Here are a few of the forming methods that yield these advantages:

DEEP DRAWING AND PRESSING. Magnesium parts are made by both deep and shallow drawing or pressing. Magnesium sheet alloys in the annealed condition may be cold drawn with a reduction of 15 to 25 per cent. Hot drawing, however, increases the reduction up to almost 70 per cent. Deeper single stage draws can be made in magnesium (when heated) than in other metals.



LARGE DEEP DRAWN PARTS can be made in a single step with magnesium alloys.

STRETCH FORMING. This highly flexible method is used in shaping large area magnesium sheets. Jaws hold opposite edges in tension while a male block or punch stretches the metal beyond its elastic range. Stretching the entire work piece insures uniform pressure at all points of contact during forming. This results in even distribution of work hardening and the elimination of localized strains. Changes in cross sectional dimensions are more uniform than with other forming methods. Hot stretch forming results in a minimum of springback.



STRETCH FORMING with magnesium alloys provides uniform properties on large sections.

RUBBER FORMING. For relatively small quantities of shallow parts, this process can be put to good use. Both hot and cold forming can be done. Dies cost much less than for other methods and design changes are easy and inexpensive to make. The principle of rubber forming is simple. A pad of rubber powered by a ram forces the work blank to assume the contour of a die directly below it.

DROP HAMMER FORMING. This method is often used for asymmetrical shapes with shallow draws, or cases where special springback control is required. Drop hammer forming is not a precision method, hence close tolerances are not possible.

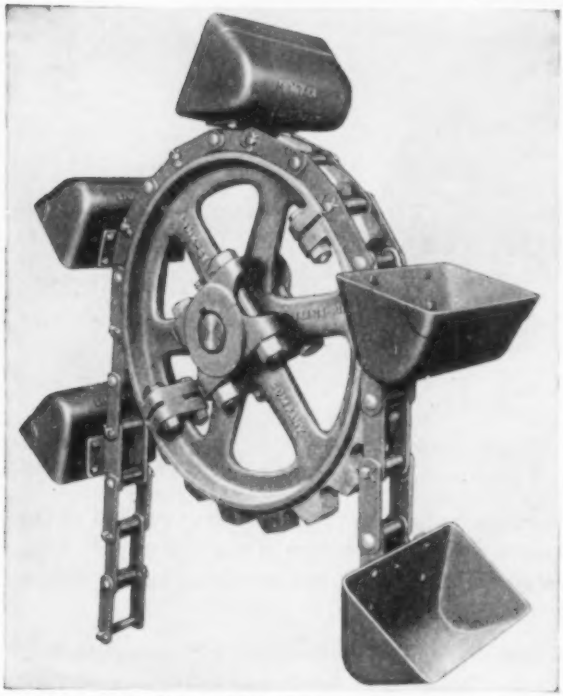
SPINNING. When a number of small parts are needed, spinning is often the most economical way to accomplish the job. However, as many as five thousand parts can sometimes be spun for less cost than when made by press forming. Spinning involves no dies, and the cost of chucks and spinning tools is relatively inexpensive.

EXTRUSION FORMABILITY. Production bending of extrusions is done on standard rolls, in mating dies, in stretch forming machines, or other specialized bending equipment. If the forming is severe, extrusions are formed hot. The bending of complex extrusions requires that bend radii be established for a given shape by the shop for its particular application.

FORMING MAGNESIUM, a 130-page handbook, covers all methods of forming discussed above, plus blanking and cutting, bending, dimpling, forging, hand forming, selection of alloys and assembly protection. Includes numerous tables on properties at temperatures, dimensions, etc. For your copy contact a Dow sales office or write THE DOW CHEMICAL COMPANY, Midland, Michigan, Dept. MA 1452V-1.

YOU CAN DEPEND ON DOW

Link-Belt SS Class bushed chain outlives previous chain 4 times



LONG, TROUBLE-FREE SERVICE of SS-111 chain (above) proves that it pays to select the right chain for a specific job from Link-Belt's complete line. It also proves that there's no need to pay a premium for costly special alloy steel chains.

Outstanding record established in severe, abrasive elevator service

This remarkable service record set by a Link-Belt SS-111 bushed chain (left) proves that often there's no need to go to excessively costly special alloy cast chains to get long life. Used at an Indianapolis (Ind.) fertilizer plant, this chain handled an average of 75,000 to 80,000 tons of fertilizer before requiring replacement. The previous type of chain handled only 18,000 tons and required four times as much maintenance.

Designed for abrasive jobs

Link-Belt SS-111 bushed chain offers large joint bearing surfaces for greater wear resistance and trouble-free service in heavy-duty conveying and elevating. Sidebars of selected bar steel are accurately formed and machined for tight press fit of pins and bushings. The latter are made from tough, hardened steel and locked against rotation in sidebars.

These straight steel sidebars with hardened steel pins and bushings provide needed strength to prevent distortion under continuous heavy loads. Smooth, tough surfaces repel gritty materials, prevent packing in critical joints, resist abrasion and corrosion.

Many sizes of these heavy-duty chains are interchangeable with Link-Belt combination chains. And a wide range of attachments makes them adaptable to specific conveying and elevating requirements.

18 million tons, 26 years later... SS-856 chain still serviceable

Sets record in cement mill elevator service

The more than quarter-century of continuous handling of raw materials at a Pennsylvania cement mill illustrates the long-wearing durability of Link-Belt SS-856 elevator chain. This amazing service record under extremely tough conditions proves that it pays to pick the right chain from Link-Belt's complete line.

Link-Belt SS-856 chain is made of high carbon steel sidebars with nickel alloy pins and bushings. Hardened sidebars give additional strength plus greater resistance to wear and pitch hole distortion. In addition, accurately machined pitch holes assure proper pitch and tight press fit of mating parts —extend chain life. The hard, smooth surfaces of steel joints repel gritty materials . . . resist abrasion.

Link-Belt elevator chains are available with ultimate strengths up to 200,000 lbs.

Link-Belt SS-102½ bushed chain extends life of stone elevator

Several years ago an eastern stone quarry installed a main bucket elevator to handle 200 tons per hour of minus 2¼-in. mixed stone. Service life of the original two-strand elevator chain was found inadequate. After several shutdowns, it was replaced with Link-Belt SS-102½ chain with K-5 attachments at every third link.

This long-life, wear-resistant chain is now in its fourth year of uninterrupted operation. It has carried close to 350,000 tons as compared to 60,000 tons which was considered normal life for the previous chain.

Recent inspection of the SS-102½ chain reveals that it is good for another long stretch of service. Elimination of shutdowns and replacements more than justified the slight difference in cost between this and the original chain.

•

STONE ELEVATOR has buckets at every third link. Centers are 65 feet, with elevator inclined 75 degrees from the grade. Chain speed is 280 feet per minute.

HEADQUARTERS for chains, sprockets and other Link-Belt conveying and mechanical power transmission products is your nearby Link-Belt Office.

LINK-BELT

CHAINS AND SPROCKETS

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office: New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World. 14,234-A

why shell castings from CENTRAL FOUNDRY DIVISION offer new design possibilities and reduced costs per part

In the shell-casting process phenolic resin is combined with sand for the mold material. This basic difference brings about a great many advantages . . .

Shell-cast castings give excellent duplication of detail since the curing of the shell on the pattern produces a hard, smooth mold which is as accurate as the pattern itself. Thus, shell molds permit deep pockets and recesses to be drawn, making possible complex designs impractical by any other method.

Central Foundry Division has been casting by the shell process since 1951. During that time, techniques have been brought to a high degree of perfection and control.

The absence of surface-sand on shell castings increases machine-tool life tremendously. At the same time, shell cast parts, being cleaner to start with, reduce or eliminate the need for additional cleaning by the customer.

The reduced machining and waste, elimination of costly cores, better surface detail, increased tool life and savings in machine scrap, combine to open countless new opportunities for you in both design and cost savings.

Perhaps shell castings can help you make your product still better and at a savings in cost. Shell castings are available in grey iron, alloy grey iron, malleable iron or ArmaSteel®. Write us today for your copies of the free, factual books, ARMASTEEL and SHELL CASTINGS. Or, tell us about your casting problems. Our research and engineering staff is ready to employ spectroanalysis, stress analysis, sonic testing, and other improved foundry methods in helping you seek a solution.

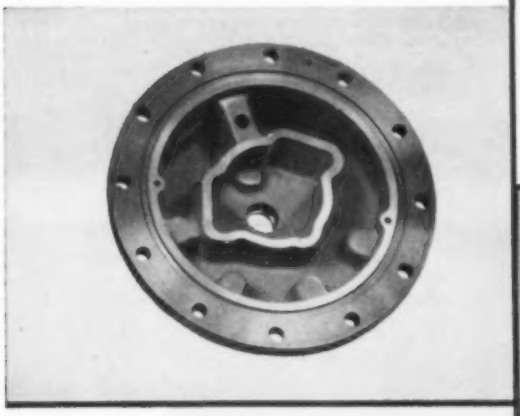
CENTRAL FOUNDRY DIVISION

GENERAL MOTORS CORPORATION • SAGINAW, MICHIGAN • DEPT. 10

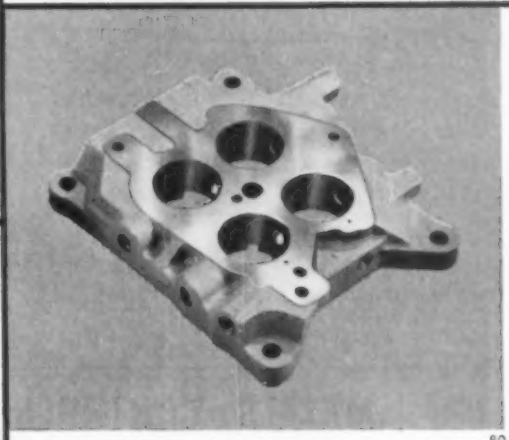
Typical shell mold showing cope and drag

Shell molding permitted the casting of intricate grooves and recesses in this governor body which would be too costly by any other method

Machining of the O.D. was eliminated by shell casting this refrigeration compressor head



Better dimensional control by the shell process simplifies the balancing of crankshafts



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Closer tolerances of shell castings often eliminate machining on clearance and non-functional surfaces

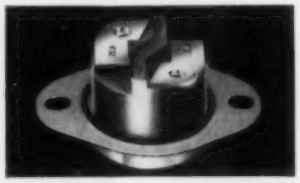
Uniformity of shell castings makes automotive rocker arms more adaptable to automatic machining

in

JOHN ZINK

JZ

Gas Heaters...



KLIXON 202 Series fixed temperature control.

KLIXON

SNAP-ACTING CONTROLS help hold field service to less than 1%

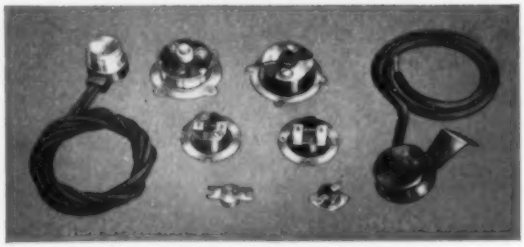
"We've specified and used KLIXON *snap-acting thermostats for several years and our field service has been held to less than 1%."*

That's how the John Zink Company of Tulsa, Oklahoma, manufacturers of this Gas Fired Forced Air High Boy Heater, feels about KLIXON Snap-Acting Controls.

The Zink Company is another of the many manufacturers who have maintained trouble-free, dependable service by using KLIXON controls. You, too, can benefit yourself and your customers by using these simple, snap-acting controls — available in many hermetically sealed and open types in a wide variety of operating temperature ranges.

Write today for catalog THSN — it gives full details on the KLIXON temperature control line.

John Zink Gas Fired Forced Air High Boy Heater.



Typical KLIXON Fixed Temperature Controls for many types of home appliances.

METALS & CONTROLS CORPORATION

Spencer Division

3805 Forest Street, Attleboro, Mass.

KLIXON

SYLVANIA'S
miniature flashbulbs give greatly increased picture-taking light.

General Plate ZIRCONIUM FOIL

Boosts Brilliance of Picture Lighting in SYLVANIA'S New Miniature Flashbulbs

In developing its new M-25 and M-5 miniature flashbulbs — bulbs that give picture-taking light equivalent to ordinary bulbs four times as large — Sylvania Electric Products Inc. chose General Plate as a dependable source for zirconium foil. And G.P. Zirconium foil plays an important part in the success of the new Sylvania bulbs, because it burns more efficiently than previously used materials, producing an ultra brilliant light burst with less internal pressure.

G.P. Zirconium foil is available in widths up to 8 inches and thicknesses down to 0.00075 inch. G.P. Zirconium sheet, rolled down to 0.014 inch thickness, can be supplied sheared or slit in widths from 14 inches to 0.030 inch.

Sylvania is another of the many hundreds of progressive firms who use General Plate's specially rolled strip and mill products — today you can get flat stock, rod, wire and many profile rolled shapes at General Plate in clad and single metals, including reactive materials such as Zirconium Zircalloy, Hafnium, Tantalum, etc.

For details on G.P. Zirconium write for bulletin IND-16 — to get acquainted with the G.P. Metal product line, write for catalog G.P. 1.

A Sendzimer Mill at General Plate rolls Zirconium foil to 0.00075 inch

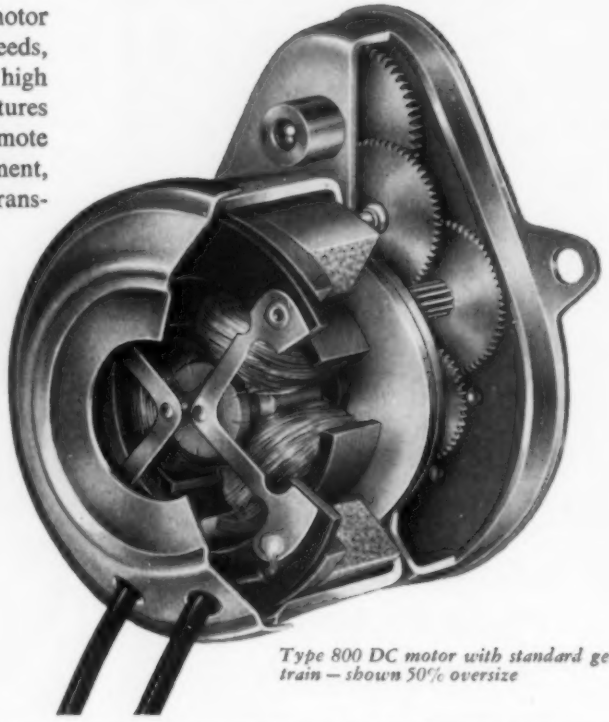
METALS & CONTROLS CORPORATION
General Plate Division 1005 Forest Street, Attleboro, Mass.

FIELD OFFICES: NEW YORK • CHICAGO • DETROIT • INDIANAPOLIS • MILWAUKEE • PASADENA

You can profit by using General Plate clad metals

New high-torque low-current DC motor covers extended range of output speeds

The new Cramer Type 800 direct current motor offers an unusually wide range of output speeds, coupled with low current drain, high torque, high efficiency, and excellent speed stability. These features make it the ideal choice for timing devices, remote control equipment, recorders, signalling equipment, communications gear, displays, flashers, chart transports, and many other products.



Type 800 DC motor with standard gear train — shown 50% oversize

Wide Performance Range

Depending on requirements of speed, torque, and voltage, the rotor is wound to produce a basic motor speed of 960 to 3000 rpm. A gear train then reduces this to the speed required at the output shaft. Low rotor speeds result in lower current drain at all speed-torque combinations, but limit the torque available at the higher output speeds. Higher rotor speeds require a somewhat higher input current, but greatly increase the torque available at the higher output speeds.

The Table at lower right illustrates this flexibility of design, with a few examples from the virtually unlimited range of performance characteristics which it provides. Where very low input current is required, and the supply voltage does not exceed 12 volts, the use of the low-speed rotor will provide 30 oz. in. at speeds below 3 rpm and 0.5 oz. in. at 200 rpm. The higher speed rotors meet the requirements of higher input voltages, and provide greatly increased torque at the higher output speeds with only a moderate increase in current drain. The high-torque motor has the additional advantage of speed stability within 10% from no-load to full-load, at speeds below 5 rpm.

The examples given in the Table are for illustration only. By correct choice of rotor winding and gear ratio, an unlimited number of operating specifications can be established throughout the entire range shown. The motor is also available without gear train, for output torques of 0.1 to 0.6 oz. in. at speeds up to 3000 rpm.

OUTPUT SPEEDS WITH GEAR TRAINS	960 RPM ROTOR LOW INPUT CURRENT (3 to 12 volts DC)		3000 RPM ROTOR HIGH OUTPUT TORQUE (3 to 30 volts DC)	
	INPUT VOLT-AMPERES	OUTPUT TORQUE OZ. IN.	INPUT VOLT-AMPERES	OUTPUT TORQUE OZ. IN.
2 rpd	.16	30	.....	.....
1/6 rpm	.16	30	.56	30
3 rpm	.35	24	.64	30
10 rpm	.35	8.5	1.04	30
30 rpm	.35	3.0	1.72	21
60 rpm	.35	1.5	1.72	12
80 rpm	.35	1.1	1.72	8.5
200 rpm	.35	.5	1.72	3.5
900 rpm	.....	.....	1.90	.8

Typical Performance of Type 800 DC Motors for Minimum Input Current or Maximum Output Torque

Specifications

SPEEDS — 2 rpd to 900 rpm with gear train, 960 rpm to 3000 rpm without gear train.

TORQUE — 0.1 to 0.6 oz. in. without gear train, and to 30 oz. in. with gear train.

CURRENT DRAIN — as low as 30 milliamperes, depending on voltage, load and speed.

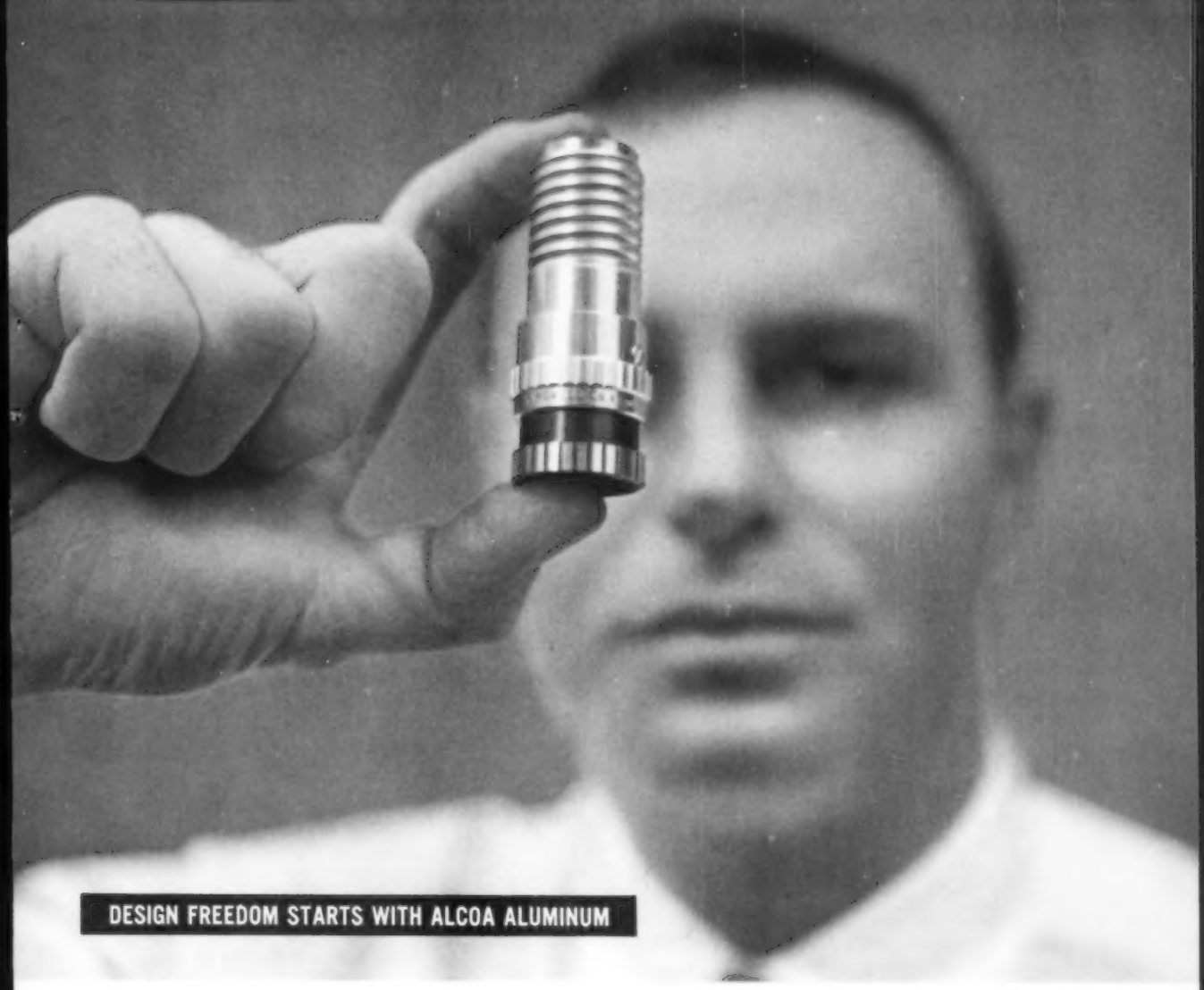
VOLTAGES — from 3 to 30 volts DC.

REVERSING OPERATION — with negligible speed difference, because of special motor design.

GEARS — precision-hobbed throughout, totally enclosed and with sealed-in lubricant.

For your free copy of informative Bulletin PB-800, write:

CRAMER CONTROLS
CORPORATION
Box 7, Centerbrook, Connecticut



BELL & HOWELL GOT COLOR • TAYLOR INSTRUMENT SAVED $100,000 ANNUALLY • DICTAPHONE REDUCED PRODUCT WEIGHT

WHAT DO YOU WANT IN SCREW MACHINE STOCK?

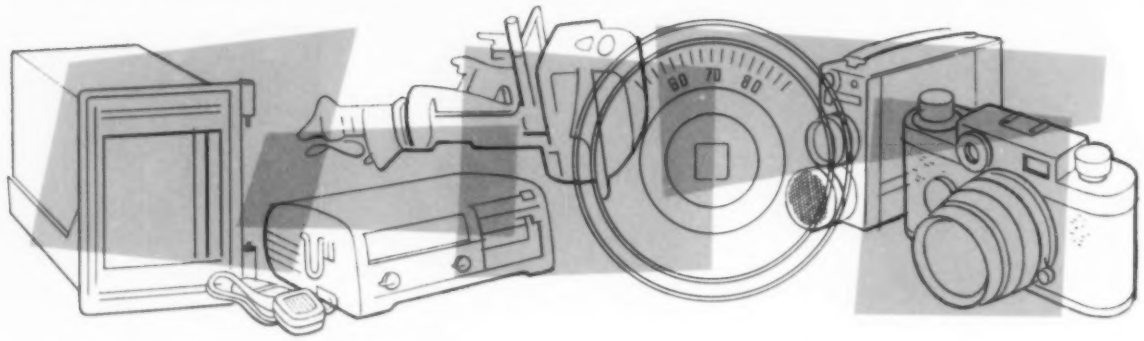
You can get parts in any color with aluminum

The designer today who wants lasting color specifies color anodizing with Alcoa® Aluminum—lustrous color that stays new and fresh because it's part of the metal—color that does not distort dimensions.

Color means eye-appeal for more sales. Would color attract more customers to your product? Bell & Howell asked this question, then switched to gold-anodized aluminum for its new Filmovara zoom projection lens. Now Alcoa Screw Machine Stock adds new beauty to a famous camera and projector line.

Color means eye-appeal for more safety. Does your product have controls where a wrong move means time, expense, accident? Square D's push-button controls electrically operate everything from single machines to assembly lines. They switched to Alcoa Aluminum Screw Machine Stock for colored buttons that are oiltight and metal rugged.

GET DESIGN FREEDOM WITH ALCOA ALUMINUM SCREW MACHINE STOCK



Result: operators now see at a glance what's what, make fewer mistakes.

Color means eye-appeal for better identification. Screw machine parts of Alcoa anodized aluminum are easier to see, stock, inventory and assemble. And color anodizing adds extra protection to aluminum's inherent resistance to corrosion.

You can cut costs with aluminum

You buy screw machine stock by the pound—you machine it by the foot. Alcoa Aluminum gives three times more parts per pound than steel or brass. Aluminum machines faster—cutting speeds as high as 1,000 feet a minute are common. Result: aluminum parts can cost less than steel or brass. It works out this way . . .

. . . aluminum vs steel: machine time makes the difference.

. . . aluminum vs brass: more parts per pound makes the difference.

Here's another way to look at it:

1. Aluminum costs less than brass, machines just as fast.
2. Aluminum machines faster than steel and won't rust.
3. Aluminum scrap allowance is higher than either.

Taylor Instrument Company proved it. By converting 40% of its parts to Alcoa Aluminum Screw Machine Stock, Taylor saved $100,000 annually. And Taylor reports performance equal to or better than other metals.

You can reduce product weight with aluminum

Designers who want less weight specify Alcoa Aluminum. Aluminum weighs less than steel or brass, so the end product weighs less. A switch to Alcoa Aluminum Screw Machine Stock played a major role in reducing the weight of Dictaphone Corporation's Time-Master dictating machine from 20 lbs to 12.4 lbs.

Aluminum weighs less than steel or brass, so it's easier on automatic screw machines and uses less power. Enterprise Manufacturing Company, maker of Pflueger fishing tackle, reports that aluminum gives longer tool life and closer tolerances on drilling, milling, tapping and machining.

Aluminum weighs less than steel or brass, so it's easier to move, stock and handle. Minneapolis-Honeywell reports that its men like aluminum's lightness, especially in the 2⅛″ size they use.

Aluminum offers superb machinability

A free-machining metal, aluminum machines as well as free-cutting brass. Aluminum is machined as fast as the machine will run. Dictaphone Corporation reports, "We chase an acme thread in aluminum with two passes, compared to six or seven in stainless."

Aluminum takes any finish

You can polish, buff, brush or burnish aluminum screw machine parts. And the initial fine appearance does not deteriorate—designers no longer need to worry about rusting. Bell & Howell reports that aluminum ensures lasting, maintenance-free color.

Aluminum scrap is worth more

Aluminum scrap brings more per pound than either steel or brass. Argus Cameras, Inc., reports that many of its parts require 75% stock removal. "Aluminum's high machinability and high scrap value help us greatly."

WHAT DOES ALL THIS MEAN TO THE DESIGNER?

Aluminum provides optimum design freedom. Aluminum gives exceptional machinability—limited almost entirely by machine capacity; high electrical and thermal conductivity; choice of any finish—or color; always less weight and frequently lower in cost than steel or brass. Summation: fewer restrictions on the designer.

For more about conversion to Alcoa Aluminum Screw Machine Stock, call your nearest Alcoa sales office. For prompt delivery of Alcoa Aluminum Screw Machine Stock, contact your local Alcoa distributor. Send for Alcoa's new booklets about aluminum screw machine stock. They contain direct quotes from design engineers, production engineers and purchasing agents of leading industries on why they switched to Alcoa Aluminum. ALUMINUM COMPANY OF AMERICA, 865-E Alcoa Building, Pittsburgh 19, Pa.

"ALCOA THEATRE"
Exciting Adventure
Alternate Monday Evenings

Look for this label. It's your guide to the best in aluminum value.
ALCOA ALUMINUM

DEVELOPMENTS TO WATCH...

Flame-retardant XXXP laminates . . .

. . . are on the way. Grade XXP has been on the market for some time; and there have been fire-resistant epoxy-glass materials. But, until recently, there were no flame-retardant materials that would meet XXXP specifications and retain their flame-retardancy for even a fraction of the life of the product.

Now, National Vulcanized Fibre says it has one ready to go that is "equal in all other properties and can be supplied with copper cladding for printed circuit use, as well as standard thicknesses (1/32 to 1/4 in.) to the regular XXXP grades." Richardson Co. of Chicago is introducing a material that "will retain its flame-retardancy for a year or more, exceeds published NEMA values for XXXP phenolic laminates, and resists arc tracking." Synthane Corp. reports that an XXXP grade is "in the developmental stage" and other laminate producers have, or expect soon to have, materials of this type.

As they point out, these new grades will be adding extra value in the form of flame resistance to products ranging from home appliances to computers and aircraft instruments while retaining advantages of the standard paper-base phenolic.

Improved thermal controls . . .

. . . are being sought by Bituminous Coal Research, Inc. in a three-step program aimed at providing a new method for automatic moisture control and a new continuous recording system.

Says BCR: Conventional control equipment now in use for drying coal and other bulk materials "fails in some cases to produce a dried product uniformly consistent in moisture content. Wide fluctuations in moisture often occur and result in complaints at destination."

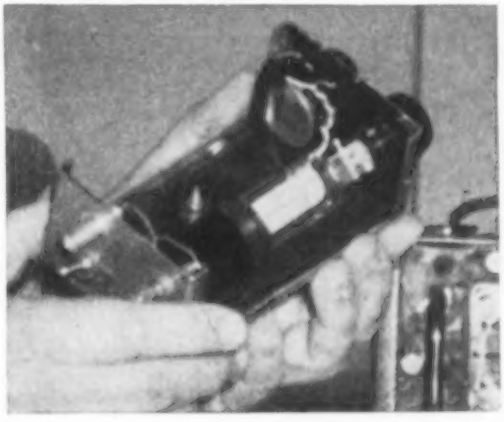
To remedy the situation, BCR plans first to study adaptation of existing moisture determination equipment to the drying of coal. Second, to develop a method whereby an electric signal obtained from moisture fluctuations in the coal stream could be simultaneously recorded on a chart and transmitted to the dryer-control system. Third, to field-test the new devices in operating plants.

For initial laboratory tests, a Quaker Rogers capacitance-type moisture controller is being used, but BCR also plans to try out resistance-type units. In the former, as BCR explains, a stream of coal passes between two electrodes, from which a signal is transmitted electrically to a recording meter. The amount of electricity flowing from the positive to the negative electrode is, in this case, an indication of the moisture content of the coal.

In the resistance-type unit, two probes are inserted in th flowing stream of coal. Change in resistance indicates variation in moisture content.

Converter-detector tube . . .

. . . that shows promise for applications as diverse as energy conversion and frequency modulation, is under test at Naval Ordnance Lab. Developed in Canada by Adalia, Ltd., it's called the "Orbitron." Adalia believes it has potential civilian applications, not only as a means for converting light or heat into electrical energy, but also as a device for measuring magnetic fields, and as an electronic component. As yet, no construction details are available; but as soon as military requirements are clarified, data will be released.



Versatile electron tube is expected to find a wide range of applications. Navy hopes to use it in sea mines, guided missiles and other electronic devices.

DEVELOPMENTS

TO WATCH...

New uses for selenium and tellurium . . .

. . . are actively being sought by the newly formed Selenium and Tellurium Development Committee through a major research program at Battelle Memorial Institute.

Tellurium has long been a "job-hungry" metal. But the idea of looking for new selenium uses would have seemed absurd a few years ago. The material was high on the stockpile list, and demand outraced supply. Now, says the latest Stockpile Report from the Office of Defense Mobilization, "Because of a large shift from selenium to silicon and germanium in the rectifier industry and substitution of mercury and cadmium for selenium in the pigment industry, stockpile acquisitions are being held to small amounts."

Like selenium, tellurium forms semiconducting compounds (lead telluride for instance). It also has ability to increase the machinability of steel and copper. But it presents problems in handling because it may be absorbed through the skin.

Battelle plans to investigate both electrical and metallurgical applications.

Communicate by ultraviolet? . . .

. . . It's more than a possibility, says Joseph L. Ryerson, Chief, Advanced Development Laboratory, Rome Air Development Center. He terms UV one of the most promising media still open for exploitation (the others: audible sound in the sea, upper atmosphere, and rock strata; and very low frequency radio in the atmosphere and rock strata).

Although ultraviolet is limited to line-of-sight transmission, low background signal and usually high bandwidth are strong recommendations. Ryerson estimates that 25,000 teletype channels, 60 wpm, would be possible. The attenuation figure (4.4×10^{-4} db) is considerably better than that of audible sound in air too.

What's needed to put it to work? Ryerson says high intensity sources of ultraviolet and suitable modulating equipment must be developed; but sees no insurmountable obstacles in the path.

Manganese antiknock compound . . .

. . . (*PE*—Apr. 7, '58, p. 5) *has passed its first tests* with flying colors, looks even better as an aid to tetraethyl lead than as a replacement, Ethyl Corp. reports. On a weight-of-metal basis, the manganese compound was "twice as effective as TEL in raising the research octane number of gasoline." But in combination with TEL, improvements by a factor as great as 6.5 were noted. The new compound seems particularly valuable when used in gasolines with a TEL content of about 3 ml/gal.

A good name, "environmental engineering" . . .

. . . is drawing attention to a new body of knowledge and a deserving problem: simulation of field environments so products can be more accurately tested and fitted to the conditions they will meet in use. It's an old problem, but new in its breadth and intensity, for both civilian and military products.

As yet, few if any engineers bear the title "environmental engineer." But an increasing number have the job, and see their function as providing the product designer with the information and testing facilities he needs.

Devising adequate tests is far from easy. As P. H. Pretz of Ford Motor Company points out, torture tests or shock courses, which attempt to evaluate vehicles too rapidly by arbitrarily increasing the severity of the operation, can be misleading. For example, a test route made up of broken beer bottles would not provide a realistic test for tire failure. But if some failures had been traced to brief periods of high-speed operation in use—normally occurring perhaps once or twice a year—these speed conditions could be reproduced several times daily, compressing the time period without radically changing the conditions, and providing an accelerated test schedule with good correlation to normal use.

In line with this philosophy, the Institute of Environmental Engineers, now just 2 years old, has set up a committee to produce a Handbook of the Environment, covering specific data on temperature, pressure, vibration, altitude, humidity, nuclear radiation. Chapters have been assigned to various members, and will be published as they are completed. The first, on low-temperature simulation and testing, is expected to be ready by August. —ARG

Aircraft Firms Try New Design Teams

SEATTLE—Boeing Airplane Co. here has announced a switch from the familiar "project" concept to the "group" concept in a recent realignment of its engineering department.

A primary reason for the reorganization, according to Boeing, is better management control. H. W. Whitington, chief engineer of the division, says, "As weapons systems and engineering organization have become more complex, the necessity for separating the management function and the actual design function has become increasingly apparent. The new setup will result in a more effective and efficient operation."

Another possible reason for the change is the trend in Air Force missile contracting. Until fairly recent years, an aircraft company was responsible to the Air Force primarily only for the airframe. This responsibility began to change with missile contracts and is changing entirely with the new weapons systems for which Boeing and other companies are submitting proposals to the Air Force.

The prime contractors becomes responsible for everything, which means all the components, subcontractors, training programs, bases, etc. Management of design, not only within the prime contractor's plant but with the various subcontractors, becomes a problem.

The *Project System*, it's generally conceded, results in a closely knit operation. The project engineer is in a position to exercise direct control, define jobs, delegate responsibility, and instill in his group a competitive feeling that gives members pride in their own accomplishments.

A *Group System* permits an organization to get people with highly developed specialized skills who could not justifiably be assigned or charged to any one single project. Similarly, better facilities and equipment are possible for a group whose operations are applied to a number of projects. Work assignments can be scheduled on an organized basis, both for personnel and equipment, so that duplication is avoided and maximum time-utilization obtained.

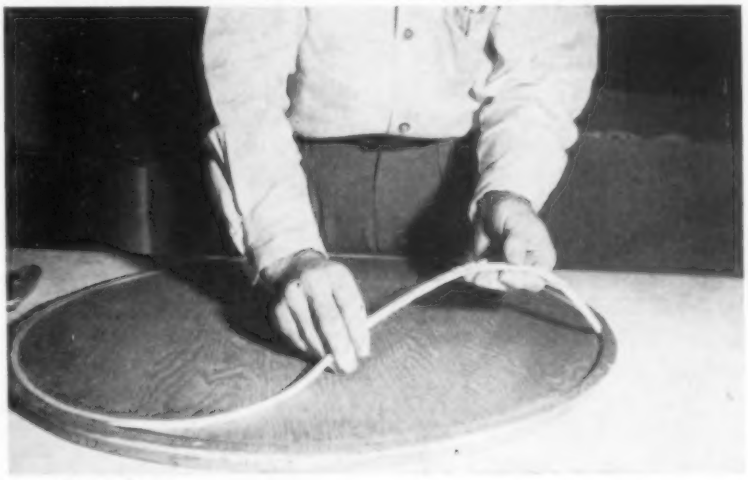
General feeling is that the state of the art is advancing so rapidly, and the products themselves are becoming so complex, that specialized groups are a necessity for minimizing the time required to turn new ideas into hardware.

Most companies in the Los Angeles area agree with this. From W. E. Woolwine, chief engineer for Northrop: "In the aircraft industry, complexity has reached the point where a 'pure' system is no longer practical for a diversified operation." Most, like Northrop, have been trying to determine the blend of the "group" and "project" organization that will best suit their own operations.

Northrop's Engineering Dept. is organized in groups (design engineering, analytical, flight test, etc.) reporting directly to G. F. Douglas, vice-pres. of engineering. To add to the flexibility of a project-oriented system, the various project offices (whose managers also report directly to Douglas) draw upon the groups for the required specialists who will be concerned with their particular projects although they continue to be members of their own groups.

Where expedient, Northrop's management sometimes sets up a "Project Team" made up of specialists temporarily separated from their own groups. In subcontract work this may be done to simplify the exchange of information with the prime contractor.

Woolwine points out that the current trend towards "fewer and bigger" weapons systems results in increased subcontracting between major aircraft companies, requiring greater attention



Pour Your Own . . .

. . . special shape silicone rubber seals of production quality at low cost is the policy of Tru-Scale, Inc., Wichita, Kansas. Reason for the special seals is the company's epoxy-glass compression and vacuum molds, which are used to produce polyester-glass prototype parts. Custom molded seals of ordinary rubber were too expensive for the special molds, and various kneaded mastics deteriorated upon contact with the polyester resin. To get around this problem, the company routed a groove of the proper cross-section out of birch-faced plywood. After filling the groove with Dow Corning's Silastic RTV, it was allowed to set overnight. The overflow was trimmed off and the seal taken out (above). The grooves could be rectangular or V-shaped as well as U-shaped, and any configuration rather than circular. Seals up to 48 in. in dia. and ¼ x ¾ in. cross-section have been made.

to the problems of intercompany communication.

At Northrop's subsidiary, Radioplane, the system is organized for the product. The more complex the product, the more group support is needed. With products ranging from relatively simple "off the shelf" radio-controlled target planes to guided nuclear missiles, Radioplane gives serious consideration to the communications burden which is part of the group system. For complex programs, the company will use a Project-Office-and-Group system, but also will turn an appreciable number of jobs over to teams made up of versatile engineers who will request group support for tasks the teams cannot solve.

Rocketdyne, Div. of North American, has just announced a Program Manager program, intended to improve the coordination and follow-up on each of the major programs handled by the company's functional divisions. An interesting feature of this program is that it sets up a Program Engineer who is responsible for customer contact as well as establishing and administering the engineering plan of action for the program. The project engineer manages a team that directs design and development work and coordinates the technical efforts.

Lockheed uses a project system, but leans heavily on specialized support groups to avoid wasteful duplication.

General Electric allows itself freedom to combine project and group systems. In situations where technology in a particular field isn't changing too much, GE says the group system alone works well. But, if the field is one of rapidly changing technology, a combination works best.

British Develop Fully Automatic Transmission

NEW YORK—A fully automatic, mechanical transmission that replaces and is competitive with a synchromesh gearbox and clutch has been developed by Hobbs Transmission Ltd. of Leamington, England.

Hydraulically activated with four speeds and reverse, the Hobbs transmission, according to its designers, is more suitable for vehicles of moderate power since it avoids power losses of a torque converter.

It has been released for use in passenger and multistop delivery vehicles that have transmissions of 61 cu in., 91.5 cu in., 152.5 cu in., and 213.5 cu in. Larger sizes up to 1100 ft/lb torque are already in service on buses, dumper trucks and rail traction. Engine sizes from 15 to 1500 cu in. and up can be accommodated.

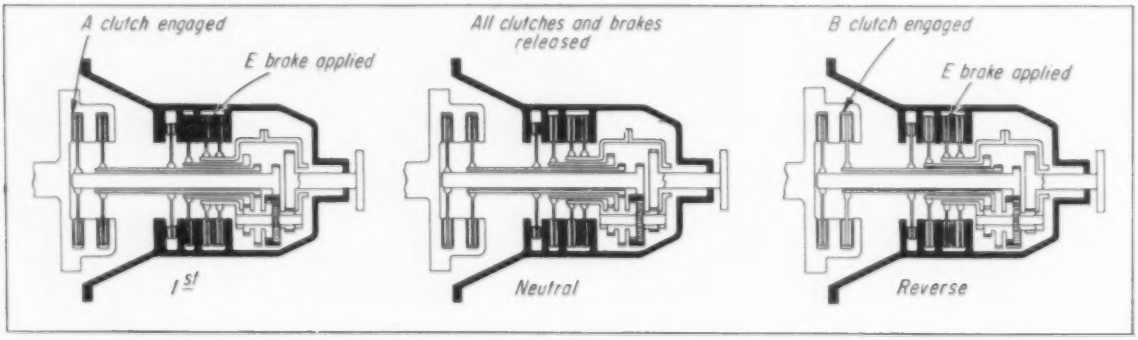
The driver has only to open the throttle. Increase of engine speed causes automatic engagement if the lever is at automatic. With the pedal fully downward at kick-down position, the gear changes take place at much higher speeds so that maximum performance can be obtained in each ratio. Drive is automatically disengaged when the vehicle stops, reducing manual effort in traffic.

Transmission is provided with overriding control while a lever can be moved into various positions giving reverse, neutral, 1st, 2nd, 3rd and automatic. Maximum safety is possible when descending hills or driving on icy roads by permitting a lower gear to be selected merely by moving the lever. The unit is designed to prevent engaging of lower gears during excessive speed, and reverse cannot be selected while going forward.

In principle, the four speeds and reverse of the Hobbs transmission are brought into operation by directing the oil pressure to the appropriate clutches and brakes. The "A" clutch is engaged for all forward ratios; to change to another ratio, just disengage one brake and engage another.

There are no compound changes involving simultaneous engagement of more than one clutch or brake. The friction surfaces are urged into engagement by hydraulic pressure enclosed by a diaphragm which forms an actuating member of about the same area as the friction surfaces.

To engage the clutch, oil under pressure delivered by a pump is led through the valves to the space enclosed by the diaphragm which transmits the pressure to the friction facings—this move is accomplished with a pressure plate. When the oil pressure is exhausted from the space, the pressure plate is disengaged by springs.



Power path of automatic transmission . . .

Three-figure diagram shows how some of the various ratios a obtained. The "A" clutch is engaged for all 'forward" ratios; to change from one ratio to another, it is only necessary to disengage one brake and engage another. There are no compound changes involving more than one clutch or brake at the same time. "B" clutch is of smaller capacity than "A" clutch as it transmits only part of the torque in direct ratio. It is used for reverse and the smaller capacity facilitates maneuverability.

Consumers' Spokesman Blasts Cars from Stem to Stern and Tailfin

WASHINGTON—An expert in the field of automobile testing and evaluation believes standard modern American cars aren't selling because their styling interferes with efficiency and passenger safety.

Laurence E. Crooks, a 20-year automotive consultant for Consumers Union of the US, put it this way in testimony before Sen. Estes Kefauver and his antitrust subcommittee:

"A large proportion of cars do not find buyers in today's market because the cars fail to come up to a tightening standard . . . of what a car should be like, what it should do, and how it should behave while doing it."

Sen. Alexander Wiley (R.-Wis.), whose home state has a perennial problem of supply and demand in dairy products, wondered if the slack demand in autos might be caused by overproduction. At least, Wiley observed, "I doubt it's because cars are too large—an awful lot of large cars were bought before."

But Crooks, admitting production and consumption have something to do with demand, stuck to his guns: "Auto buyers are backing away from dreamboats to look for something more practical, and wondering why all the enthusiasm about those little foreign cars." He added parenthetically, "My testing staff isn't wondering, we have tested 37 small foreign cars, of 20 different brands."

Crooks said his organization ordinarily says little about styling unless it interferes with the car's functioning or with the driver's functioning. But he didn't mind telling Kefauver: "Sometimes it seems as though modern styling was created only to hinder both car and driver. Things aren't that innocent, though; when a styling feature vies with a practical feature, or a safety feature, styling usually wins." One of Crooks' examples: "The sharp ridge formed across the lower edge of the sharp instrument panel on the 1958 Chevrolet. Its decorative value is nil, its safety value negative—every schoolboy knows a sharp edge will cut deeper on impact than a flat surface."

The main objection to styling, said the shoppers' expert, is that manufacturers let it "ride roughshod" over other characteristics in a car—headroom, for one—which could lead to more efficient, safer operation or to greater comfort. There is no reason why cars cannot be built so motorists could travel 50 mph with the windows open, yet not suffer wind noise or wind blast, he said.

Crooks admitted the late model cars steer better, handle better, ride better—in short, the "low look is not without reward." Glass area has increased and Crooks likes this too.

But he finds quality is "going downhill": On a batch of twenty 1958 cars tested by Consumers Union, defects ran from noisy axle gears, a hole in a cylinder, many broken speedometer cables, to improperly aimed headlights. Quipped Crooks, "This is not a convincing argument that 'you auto buy now'."

Most of all, Crooks criticized the manufacturers for overemphasizing horsepower, which has added to operating cost in wear and durability. "The charm, but not the cost, of going from 0 to 60 mph in 10 seconds is, I suspect, dubious."

New York Hosts 4th Automation Show

NEW YORK—The Fourth International Automation Exposition and Congress will be held on June 9-13 at the New York Coliseum with more than 175 exhibitors in attendance and 14 technical sessions with 40 papers scheduled. In addition, many companies have scheduled 90-minute exhibitor clinics of lecture-demonstrations based on operating equipment.

Titles of a few of the papers are: Automatic Manufacture for High Production; Automating a Large Low Volume Product; The Effective Selection of Measurements for Process Control; Electrohydraulic Relays in Control Systems; Automatic Control of Aircraft; Automatic Weighing While Conveying; Making Automation Work; Automatic Reduction of Laboratory Data; Cybernetic Machines in Industry; Automation of Integrated Production Lines; and others.

Robert W. Carson, Managing Editor of PRODUCT ENGINEERING and Robert E. Abbott, Associate Editor, each will chairman one of the technical sessions.

Coming Events

MAY

26-28 . . . . National Office Machinery and Equipment Exposition sponsored by National Office Management Association. Conrad Hilton Hotel, Chicago.

27-28 . . . . Electronic Industries Association, second conference on Maintainability of Electronic Equipment. University of Pennsylvania, Philadelphia, Penna.

JUNE

1-6 . . . . Industrial Research Conference sponsored by Department of Industrial and Management Engineering, Columbia Univ, at Arden House, Harriman, N. Y.

1-4 . . . . American Gear Manufacturers Association, 42nd annual meeting at The Homestead, Hot Springs, Va.

2-6 . . . . American Society for Testing Materials, 6th annual meeting on mass spectrometry at Jung Hotel, New Orleans.

2-4 . . . . National Fluid Power Association, spring meeting, Bedford Springs hotel, Bedford, Penna.

4-5 . . . . Pressed Metal Institute, management meeting, Hotel Carter, Cleveland, Ohio.

9-12 . . . . Materials Handling Conference, sponsored by ASME at Public Auditorium, Cleveland, Ohio.

9-21 . . . . International Organization for Standardization, Triennial meeting, Harrogate, England.

AUGUST

19-22 . . . . Western Electronic Show and Convention, at Pan Pacific Auditorium, Los Angeles.

SEPTEMBER

24-25 . . . . Institute of Radio Engineers, 7th annual symposium on Industrial Electronics, at Rackham Memorial Auditorium, Detroit, Mich.

OCTOBER

5-8 . . . . National Association of Corrosion Engineers, Northeast Regional Meeting at Watertown Arsenal Labs., Watertown, Mass.

Sintering Concepts Contradicted

PHILADELPHIA—How do metal particles get sintered into useful shapes? This phenomenon has been explained in several ways, but generally it is theorized that the action occurs between definable uniform shapes and spaces. Actually, such is not the case.

The metal particles always are irregular in both size and form, and are tumbled together in random fashion. This has meant that geometric models of sintered structures used as a basis of theories to explain the process generally have led to disappointing results.

APPLY TOPOLOGICAL GEOMETRY

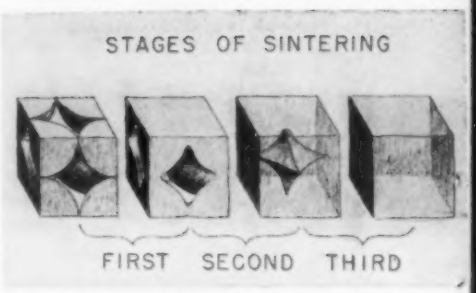
At the recent annual meeting of the Metal Powder Association here, Professor F. N. Rhines of Carnegie Institute of Technology proposed an application of topological geometry to this problem. This new approach seems to permit an explanation of the interrelationship of the particles and spaces in a metal powder compact, both immediately after compaction and throughout the sintering process, as the particles join together at one or more weld points, and as internal channels shrink, divide, or disappear.

Within the framework provided by Rhine's work, sintering can be divided into three sequential stages, which correspond to periods of weld neck growth, formation of closed pores, and the disappearance of porosity.

Sintering, which is a single geometric process that reduces total surface area, shows four almost independent functions: densification, rounding of internal surfaces, closure of interpore-connections and segregation of porosity into fewer but larger spaces.

Densification is caused only by plastic deformation, except in the surface layer and during the final stage when average pore-to-surface distance approaches half thickness of the body. Local rounding and minimization of surface area of the porosity can be effected by vapor transport, surface diffusion, volume diffusion, and plastic flow. Because the vapor transport's effect may be controlled by varying the atmospheric pressure in the sintering furnace, the rate of rounding may be varied independently of other kinds of geometric changes.

Closure of interpore connections must result either from pre-compaction of the powder mass, or from densification by plastic flow. Closure may be completed by local surface area minimization.



Three stages of sintering . . .
. . . are represented by compacted particles (first model, left) before the growth of weld-necks has begun in sintering. In the second model, the weld-neck growth has just reached the stage at which some faces have closed. All faces have closed in the third model, isolating the internal cavity. The fourth model shows complete disappearance of all voids.

AEC Travelling 4 Fusion Roads

WASHINGTON—The Atomic Energy Commission is seriously pursuing not one, but four routes to the goal of making electric power through controlled thermonuclear fusion. They won't be completely unveiled until next September's meeting of leading atomic scientists at Geneva.

Three would-be fusion devices are being developed, in addition to the "pinch bottle" disclosed by AEC last January. None has achieved a thermonuclear reaction as yet, and a working fusion reactor is still years away.

All four experimental methods involve attempts to heat and compress ionized deuterium (heavy hydrogen) until charged particles are heated to 100 million degrees centigrade or more and fusion occurs. The trouble comes in keeping the neutrons away from walls of the container. In the pinch bottle, this is done by magnetic fields inside the container to "pinch" the gas away from the walls.

The three newer devices involve efforts to confine the gas by (1) applying an external magnetic field, then superheating the charged particles with a pulsating "magnetic pump," (2) trapping the particles inside a football-shaped "magnetic bottle," within which they are bounced back and forth thousands of times, and (3) getting off to a head start by injecting particles which already are superhot into a magnetic container.

Although AEC officials indicate guardedly they expect to make a good showing at Geneva, they warn there's no proof it will ever be practical to make power by such methods.

Timken Automates Railroad Bearing Plant

COLUMBUS, OHIO—"Boxcar hotboxes" may be only history if the brainchild of C. L. Eastburg, assistant chief engineer of Timken Roller Bearing Company's Railway Div., can lower buying resistance of US railroads. It is a factory-sealed, pregreased roller bearing package to fit all American Association of Railroads axles, and Timken has gambled $7,000,000 on an automatic plant here to make them.

The venture resulted from a worldwide study Mr. Eastburg made several years ago, after which he designed a practical conversion method to apply these bearings in place of the original sleeve bearings on any US and most foreign railroad wheel assemblies, without scrapping axles or frames. More important, he helped persuade the big 3 (Timken SKF, Hyatt) to swallow differences and come up with standard interchangeable kits.

The Timken facility here starts with steel bars and tubes (made of 4620 or special Krupp steel from Timken's own mills) and delivers pre-greased precision railway journal bearings ready for shipment. Each machine gages its own work with automatic pneumatic or electric gages. Deviations are automatically corrected with no human help. The 26 operators per shift do not directly handle the pieces, but

spot check for accuracy, and change grinding wheels and cutters. Output is about 30 bearings per hour, and this can be for 3 shifts per day.

The controls, although automatic, are simple to understand. John Rundt, chief engineer of Research and Development, felt that exotic controls could quickly double the price of a machine, eliminating profit. Electrical, mechanical, pneumatic and hydraulic controls shared about equal status throughout the operation. Rundt was unwilling to state preference of one over another, because each does a variety of jobs. Although Timken specified the performance and recommended the general design of each machine, the machine builders selected the components from their own preferred sources. Hydraulic control panels are vertical, like electric control panels.

Emphasis is on close automatic quality control. Pneumatic in-process gages hold production tolerances to 0.00005 inch. An electronic surface checker using phototubes completely scans 45 rapidly rotating bearing rollers per minute, and throws out any that are scratched.

Carburizing and heat treating is virtually unattended–a major accomplishment, first of its size. The Surface Combustion Corp. furnace (about 100 x 50 ft including auxiliaries) performs 15 major operations, continuously delivering parts with 59 to 61 Rockwell C hardness down to 0.06 in. depth. Carburizing atmosphere is special RX gas made on the spot, and temperature is held at 1700 F. Parts are variously heated, quenched, washed, dried, reheated, etc.

Pres. W. E. Unstaddt and his staff feel that India, England and South Africa are ahead of the US by jumping on the roller-bearing bandwagon. Sleeve bearings are referred to as "friction bearings" at Timken, and they claim data to prove that overheating occurs 1500 times more frequently in sleeve railway journals than roller. To this advantage Timken says that roller bearings add lower friction, lower weight, vastly simpler inspection, predicting an estimated saving (if all railroads change over) of $244,000,000 per year. It is also convinced that despite the current recession, every railroad must eventually make this economy maneuver. At present, however, orders are still few.

Sylvania Dedicates New Plant; Irvine Lists Future Projects

WILLIAMSVILLE, N. Y.—The president of Sylvania Electric Products, Don Mitchell, predicted that $5 billion of the nation's expected $47.3 billion defense spending plans will be spent for electronics. The occasion was the opening of Sylvania's new Amherst Engineering Lab in this Buffalo suburb.

The dedication indicated the stress placed on electronics as a weapon in itself, and the steps that companies like Sylvania are taking to get into the systems end of the business. (Sylvania's Electronic Div. is prime contractor and weapon system manager for PLATO, an anti-missile missile system for defense of field armies).

It also showed how electronics manufacturers are moving in on a field once monopolized by the airframe industry, (PE—May 19, '58, p. 7). The Williamsville lab will specialize in the field of countermeasures, radar, navigation, and communications.

Lt. General C. S. Irvine, Air Force Deputy Chief of Staff, Materiel, guest speaker at the dedication said that both piloted vehicles and missiles will be essential to Air Force needs.

"The sequence of progression with piloted vehicles from now on starts with a new version of the long range bomber, the B52G, now in production. It will have greater range and countermeasure capabilities than its predecessor; its firepower is increased with the Hound Dog air-to-surface guided missile.

"The B-58 supersonic bomber is approaching the operational stage and will replace the B-47 and provide supersonic support for the B-52's. The B-58 will be operational at altitudes well over 70,000 ft. and at speeds over Mach 2."

Departing from his prepared speech, Gen. Irvine said that "It disproves the people with 22-cal. minds who said the B-58 wouldn't fly, wouldn't meet the range and speed requirements, and wouldn't do what it was supposed to. "In fact," Gen. Irvine said "it has exceeded both range and speed requirements."

Speaking of the B-58, this plant dedication was different than most. The curtain covering the dedication plaque was rigged to open on voice command. Whose voice? That of the pilot of a B-58 which swooshed low over the new lab. at the appropriate time in the ceremonies.

General Irvine said that the next generation of piloted air vehicles will include the B-70 (chemical bomber) and a long range interceptor—the F-108. In all probability they will be a radical departure from present configurations. Operational altitudes will be above 75,000 ft. at speeds over mach 3. Radar systems for these planes will have far greater range than do those of today.

"Beyond these," General Irvine said, "the next generation of piloted weapons systems will be space vehicles. The next step will be the X-15 at 3,600 mph. After that the DYNA-SOAR project which will put man in orbit for one or more trips around the earth."

Stage Competition for Design of Plastic Products

CHICAGO—To stimulate the use of plastic materials in new products and the improvement of other products through the use of plastics, the Chicago Molded Plastics Corp., Chicago, Ill., is running the Bachner Award competition.

This competition is open to any person or organization engaged in the manufacture of products which are made partially or totally of plastics, which are molded, extruded, vacuum or pressure formed of either thermoplastic or thermosetting plastics. All parts must be recent production items not commercially available prior to Jan. 1957.

The prize is $1,000, plus a plaque to the winning person or company. The contest closes Aug. 15, 1958 and the winner will be announced at the Plastics Show in Chicago in November. For further information, write to W. T. Cruse, Society of the Plastics Industry, 250 Park Ave., N. Y. 17, N. Y.

Cleaner Fuels Arrive

LINDEN, N. J.—Reduced engine deposits and more power for the gasoline dollar are promised by Esso Standard Oil Co. as a result of research with radioisotopes and ultraviolet light. The developments include a new combustion control agent as well as a new-type gasoline.

It had long been known, says Esso, that some of the hydrocarbons in petroleum have a much greater tendency to form engine deposits. But the problem was: which ones? To find out, Esso Research and Engineering turned to radioisotope-labeled compounds—compounds in which "normal" carbon is replaced by readily detected radioactive carbon 14. These studies showed that the deposit-forming hydrocarbons were primarily the heavy (high boiling) aromatics.

Next step was to detect them so they could be removed. Here ultraviolet light supplied the answer. Absorption of ultraviolet radiation, says Esso, is a good indicator. Except for the heavy aromatics, the constituents of gasoline let ultraviolet pass through without hindrance, X-ray fashion.

Esso admits that removal of these compounds does not solve every combustion chamber problem. There are, unavoidably, some deposits left—and these are being attacked with the new combustion control agent.

The new controlled-hydrocarbon gasolines, with the new combustion control agent, are now moving into the general consumer field in the form of New Formula "Golden" and "Esso Extra" gasolines that will, Esso predicts, "outperform gasolines costing 2¢ and 3¢ more."

Esso's research on this project lasted 3½ years and involved more than a million miles of road tests. Scientists at the Research Center believe that the basic knowledge required to produce the favorable results could not have been obtained by any other method than radiation research. Only about 15% of a modern motor fuel is as nature formed it: the rest has been chemically altered. General refinery change-over and movement of the new gasolines to bulk storage was begun about two months ago. Esso says that its premium gasoline ratio has increased more than 10% since its introduction of three-grade marketing.

READER TO EDITOR

Copper Under the Sun

To the Editor:

We are very much interested in solar heating activity and are quite familiar with the houses listed in your news story (Mar. 10, p. 26). You give credit to aluminum sheet as the radiant absorbing surface in the MIT House but this necessitates the use of copper tubes which are serpentined and fastened on to the aluminum sheet. A more efficient system has been used in the Arizona House where Revere copper Tube-In-Strip is used as the solar collecting surfaces in the movable louvers.

We find that, with the exception of the MIT House, Revere copper Tube-In-Strip is doing the work for solar collecting surfaces where water systems are used. In addition to hot water systems, hot air systems have been designed into some installations. Considerable work in the past was done with glass, such as the current house in Denver. However, we find that aluminum Tube-In-Strip is now being designed in hot air systems where corrosion is not a problem.

—C. J. PLOVANICH
Revere Copper and Brass Inc.
New York City

Living Language

To the Editor:

Don't let literary prudes keep you from using live language like "exotic metals" (Mar. 17, p. 66). My Webster's *New Collegiate Dictionary* gives "excitingly strange" as one of the definitions of "exotic." What better?

—ROY CRABTREE
Florence, Ala.

Engineers—Part of Management

To the Editor:

Mr. Amann unwittingly has singled out the real reason that engineers oppose an engineers' union. ("Points of View," Apr. 21, p. 37). He comments that (EJC's) "salary surveys . . . are . . . heavily distorted by including the salaries of engineering managers. . . ." Engineers in most companies are at present considered part of management rather than labor. Furthermore, engineers are sharply restricted in promotional opportunities as long as they remain engineers. The only hope that an ambitious engineer has to gain a high salary, an important position, and great prestige is to become an engineering manager.

If engineers formed a union and engaged in collective bargaining, management would from that time consider them beyond the pale. They would be supervised by people who have never been engineers, who do not understand engineers or their problems, and who would regard engineers as clever technicians. They prefer to remain on the side of management, and someday, just possibly, help distort EJC's salary survey.

—JAMES D. SUTHERLAND
Oxnard, Calif.

Pen Name

To the Editor:

The derivation of words denoting writing instruments ("Interesting to Note," Apr. 14, p. 7) is interesting: Our *pen* is undoubtedly a cognate of the Italian *penna* meaning a feather as well as a pen, and indicates what the pen used to be made of. The French probably wrote more softly: they used a *plume*. As for lead, Cennino Cennini, in a book on art, written probably after 1396 and certainly finished before 1437, has the following:

"*Anchora puoi . . . disengniare . . . con istile di pionbo; cioe fatto lo stile due parti pionbo, e la parte stangno, ben battuto a martellino.* (You can also draw with a lead stick; made of two parts lead and one part tin, well beaten with a small hammer.")

As for *penicellum* your derivation is correct, as far as it goes. The *cellum* part of it is the diminutive suffix, translated "little" (could also be "thin").

Incidentally, there is even a possibility that our good Cennino may have used graphite:

Also to draw I have found a certain black stone, which comes from Piedmont, which is a soft stone; and you can sharpen it with a pen knife, for it is soft. And very black. This is from Cennini's *Il Libro dell 'Arte*, as edited by Daniel V. Thompson, Jr.

—FELIX GIORDANO
Detroit

DOW CORNING CORPORATION

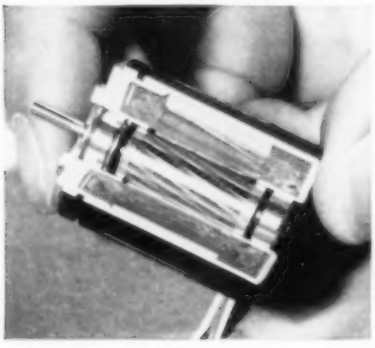
Silicone News

FOR DESIGN ENGINEERS No. 50

"SEAL IN" DEPENDABILITY WITH SILICONE RESIN

Engineers at G-M Laboratories, Inc., Chicago, take no chances on the performance of servo motors intended for high temperature or high humidity service. They virtually "seal in" dependability by impregnating the stator coils with heat-stable, moisture-proof Dow Corning 7501 Resin.

G-M Laboratories, Inc., blends this solventless, silicone resin with a suitable inorganic filler, impregnates the stator coil assembly by vacuum-filling and then cures the unit in an inert atmosphere.



The cutaway photo illustrates how the resin completely fills up the coil interstices and provides a solid, bubble-free mass inside the case. As a result, the *(Cont. Pg. 2)*

NEW LAMINATES WITHSTAND 1200F

Heat-reflective silicone-glass laminated parts that actually repel heat and withstand exposure to temperatures as high as 1200 F are now produced by Swedlow Plastics Company, Los Angeles, for use as heat dams and as light, heat-stable structural parts.

By metallizing one side of the silicone-glass laminate, Swedlow has increased heat reflecting efficiency markedly. When this metallized surface is exposed to 1200 F, the maximum temperature on the other side of the laminate is only 490 F and the air temperature 3/8 inches away is 260 F . . . an overall temperature reduction of nearly a thousand degrees.

Structural parts made from heat-reflective, silicone-glass laminate provide a new level of strength-to-weight at high temperatures. They weigh only 0.530 pound per square foot for 0.0625 inch sections. They are easy to mold, easy to fabricate and are used as heat dams on numerous aircraft. On North American's F-100, for example, this new material has replaced metal shields covered with aluminum foil to protect the wiring in the afterburner area. The new "Heat Reflective Plastic" offers many advantages for applications ranging from missiles to hot water tanks . . . wherever protection from high temperatures is a factor. *No. 506*

Versatile Solenoids More Reliable With Sylkyd Enameled Magnet Wire

New evidence of the high temperature performance possible by using magnet wire coated with Dow Corning Sylkyd* Enamel comes from West Coast Electrical Manufacturing Corporation, Los Angeles, producer of miniature solenoids for aircraft missiles.

West Coast Electrical uses Sylkyd enameled magnet wire on their Wesco A-4, a 4 oz. continuous duty solenoid exerting a three pound pull at a 1/16" stroke. The Sylkyd enameled wire increases reliability and ups allowable ambients to 250 F, permitting total operating temperature of 500 F. By making it possible to locate the unit closer to the work, the solenoid becomes even more versatile.

Their engineers likewise specify Sylkyd enameled wire for the intermittent-duty Wesco A-1, a tiny 2½ ounce unit designed to pull 3½ pounds at 1/16" stroke. Sylkyd's great heat stability increases the operating interval of this unit as much as 70 to 100% and at the same time multiplies its rated service life by five! *No. 507*

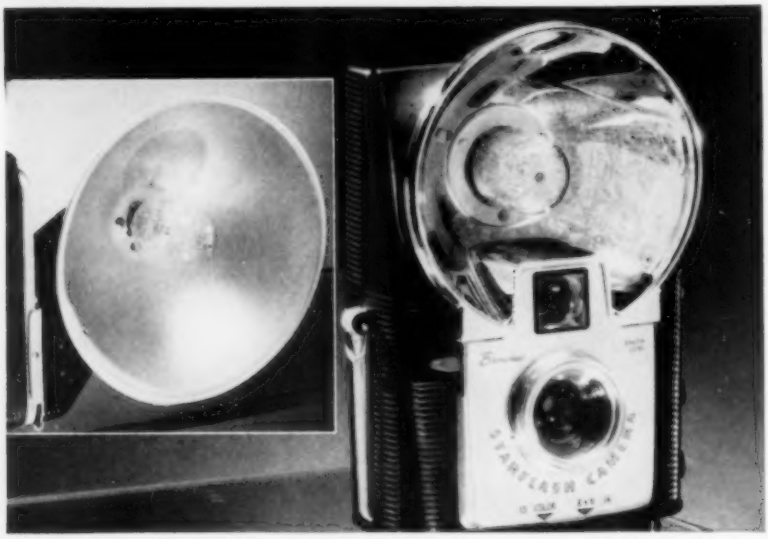
*T.M.REG.U.S.PAT.OFF.

FOR DATA RELATING TO THESE ARTICLES, CIRCLE REFERENCE NUMBER IN COUPON ON NEXT PAGE

MORE

DOW CORNING CORPORATION

Silicone News



Invisible Silicone Film Protects Reflector Finish

Eastman Kodak has found that an easy and practical way to protect the finish on its newest photoflash reflectors is to apply an invisible but durable silicone film.

The vacuum-metallized plastic surface on Eastman's new photoflash reflectors has far more reflective power than old style satin-finished aluminum units and represents a new high in reflector efficiency.

To assure maximum user benefit, the company has taken every precaution to safeguard this finish. After the reflectors are vacuum-coated, they get a clear coat of varnish which is topped off by a dip in a solution of Dow Corning 200 Fluid.

According to Eastman: "Experimentation has established that a very light application of silicone fluid to the reflector surface reduces finger-printing and increases scratch and abrasion resistance.

"The silicone film is applied by dipping the reflectors in a 0.2% solution of Dow Corning 200 Fluid of 33 centistokes viscosity in low-flash naphtha. The naphtha is allowed to evaporate before the reflectors are packaged."

Excellent wetting and spreading characteristics of Dow Corning 200 Fluid provide a practical means of applying a smooth, continuous, nonoily film that is invisible, dry, heat-stable and water repellent. Its resistance to oxidation makes it an excellent nongumming, durable film. *No. 508*

"SEAL IN" DEPENDABILITY *(Cont.)*

stator coils are completely protected against vibration, oxidation, corona, and moisture despite high temperature service. Even after 100 hours at 300 F, for example, leakage resistance of the 5600 rpm motor shown is 500 megohms at 500 volts dc.

Other Facts About 7501 Resin: This solventless, silicone resin has excellent dielectric properties and good thermal conductivity. It will withstand continuous service at 400 F and intermittent exposure up to 500 F. Dow Corning 7501 Resin is ideal for impregnating or encapsulating miniature motors, transformers, electrical and electronic assemblies. *No. 509*

NEW LITERATURE AND TECHNICAL DATA ON SILICONES

"Reactive Silicone Resin Intermediates" recently published in Paint and Varnish Production cites advantages and limitations of copolymerizing silicone intermediates with epoxies or short, medium and long oil alkyds. *No. 510*

Silastic Adhesive S-2200, an easily applied, quick vulcanizing material, effectively bonds silicone rubber to metals or to silicone rubber itself. Tests affirm its marked superiority over previously available adhesives. *No. 511*

"A New Diffusion Pump Fluid" reprinted from VACUUM SYMPOSIUM TRANSACTIONS is a comprehensive report on the properties and advantages of a new diffusion pump fluid recently made commercially available by Dow Corning Corporation. *No. 512*

1958 Guide to Dow Corning Silicones—consists of 16 pages filled with data and illustrations suggesting ways in which you can cut costs, simplify designs, improve performance and add new sales appeal to your products with Dow Corning Silicones. Cross indexed for handy reference, this all-new Guide includes properties and uses for the silicone products developed in recent months. *No. 513*

Antifoam B, the lowest priced silicone foam-killer, has greater stability than any other water dilutable silicone defoamer commercially available. Antifoam B will not separate, oil out, settle or precipitate in most applications; retains uniformity and effectiveness even under adverse storage or operating conditions. Ready to use, it requires no diluting or pre-mixing. *No. 514*

Protective Finishes and Maintenance Paints, made with Dow Corning Silicones, are available from more than 50 formulators listed in a 4-page brochure that describes how these heat, moisture, and oxidation resistant coatings improve product finishing, and reduce maintenance costs. *No. 515*

Dow Corning Corporation, Dept. 865, Midland, Michigan

Please send me: 506 507 508 509 510 511 512 513 514 515

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SILICONE NEWS is published for product design and development engineers by

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Dow Corning CORPORATION

MIDLAND, MICHIGAN

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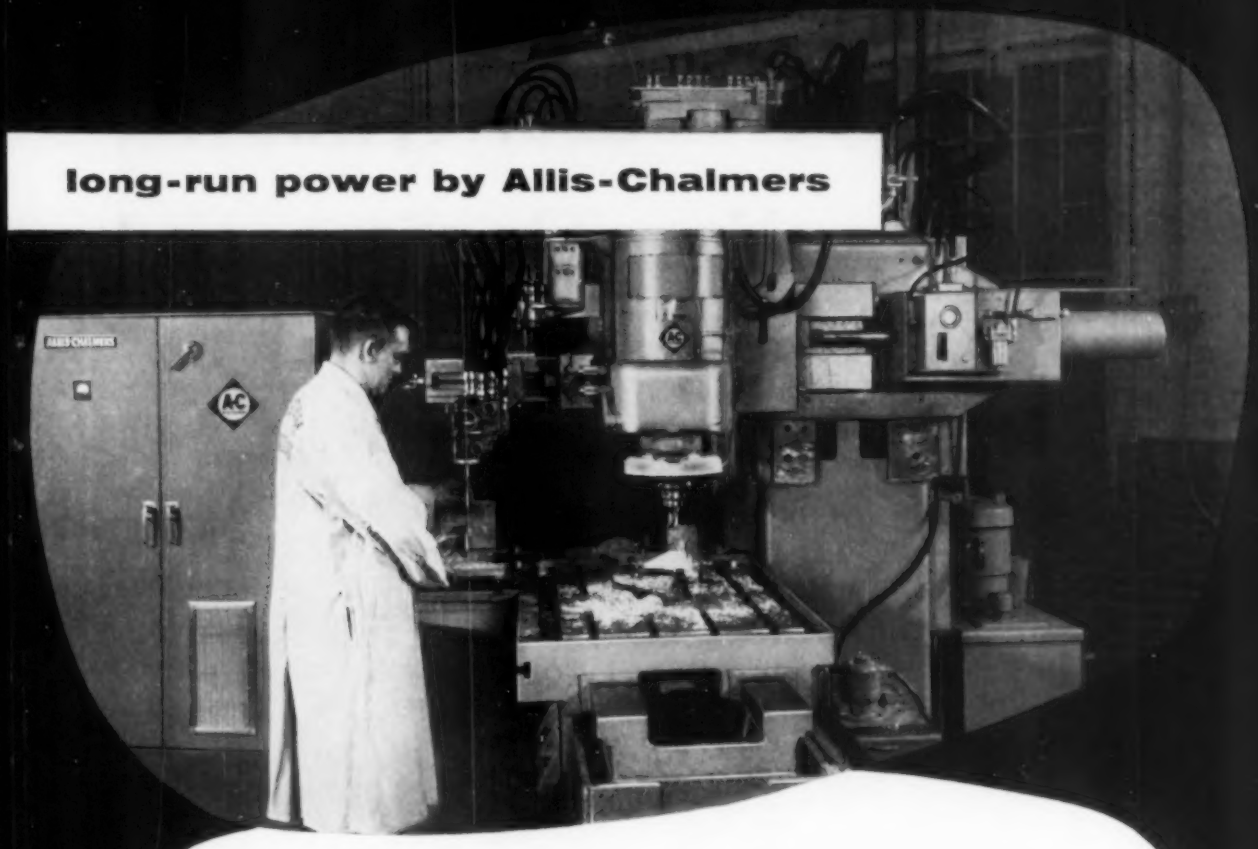
CANADA: DOW CORNING SILICONES LTD., TORONTO GREAT BRITAIN: MIDLAND SILICONES LTD., LONDON FRANCE: ST. GOBAIN, PARIS

long-run power by Allis-Chalmers



NOW AVAILABLE— 50 to 6000 rpm shell-type, dc water-cooled motor with static controller

THIS infinitely variable-speed motor and control system was designed for a machine tool company for its profile milling machines. Reason: air-frame and missile builders require all-purpose motorized spindles for machining titanium, steel and aluminum.

Special Allis-Chalmers engineering provided a dc shell motor and static control to perform this duty. *With the equipment went A-C assurance of nation-wide engineering service to back operation in the field.*

This is one example of A-C engineering skill. Combined with a broad line of standard motors and national service, it can mean real benefits for your process or equipment.

Contact your A-C representative, or write Allis-Chalmers, General Products Division, Milwaukee 1, Wisconsin.

CLOSE-UP of new Allis-Chalmers dc shell motor mounted in customer's housing illustrates compactness. It is water-cooled and has oil-mist lubrication.

STATIC GRID CONTROL, newly developed by Allis-Chalmers, has thyratrons to allow for high and low speed range, and automatic acceleration through the entire range.

A-5730

ALLIS-CHALMERS

T-J spacemaker cylinder

Quality Engineered

to give quality results

with Extras . . . at No Extra Cost!

You get more—much more—when you specify and use any of T-J's complete line of Spacemaker cylinders. The Spacemaker is engineered to give you better, more accurate, and longer service—offers, exclusively, many extras . . . that are STANDARD, AT NO EXTRA COST!

Designed to eliminate tie-rods, providing greater strength . . . saves space . . . reduces manhours and costs in all push-pull-lift operations. OFF SHELF DELIVERY in a wide range of styles and capacities, with 64,000 combinations. Write for catalog SM 56-2 with complete engineering details. The Tomkins-Johnson Co., Jackson, Mich.

T-J TOMKINS-JOHNSON
RIVETORS AIR AND HYDRAULIC CYLINDERS CUTTERS CLINCHORS

METAL PISTON ROD SCRAPER . . . Standard at No Extra Cost!

NEW "SUPER" CUSHION FOR AIR . . . Standard at No Extra Cost!

CHROME PLATED CYLINDER BORES AND PISTON RODS . . . Standard at No Extra Cost!

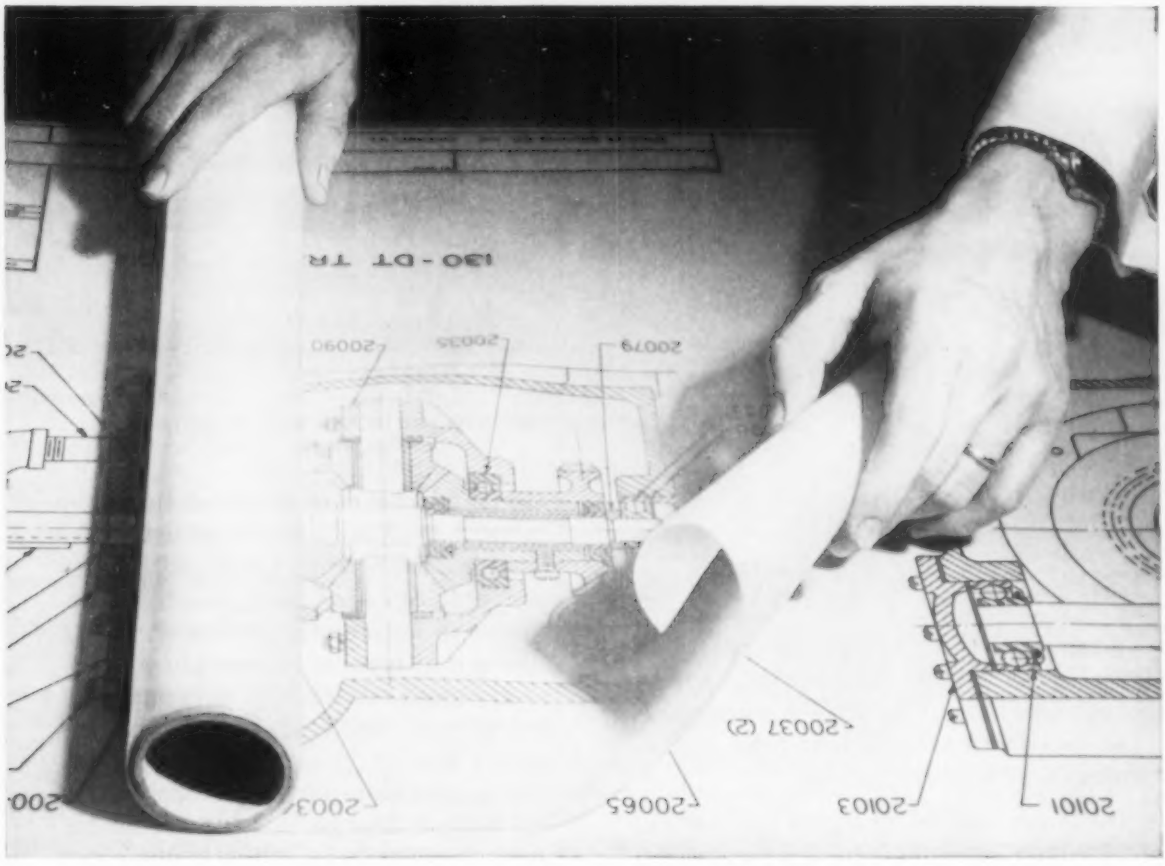
ONE PIECE PISTON . . . Standard at No Extra Cost!

NEW "SELF-ALIGNING" MASTER CUSHION FOR HYDRAULIC USE . . . Standard at No Extra Cost!

NO TIE-RODS TO STRETCH . . . Standard at No Extra Cost!

STREAMLINED DESIGN . . . Oil Pressure to 750 P.S.I.—air to 200 P.S.I. Standard at No Extra Cost!

FORGED SOLID STEEL HEADS . . . Standard at No Extra Cost!



Easy To See Through This Tracing Paper!

You'll make no mistake, nor will your draftsmen, with Bruning's improved "Frenchvel" Tracing Paper—you can see *right* through it. The second you put "Frenchvel" over a weak-lined drawing or blueprint, its remarkably high translucency reveals everything. Your draftsmen will trace faster and better because they see what they're tracing more clearly. In your reproduction machines, "Frenchvel" will give you faster reproduction, produce sharp, clear prints.

In addition to its greater translucency—brought by an improved transparentizing agent and technique of application—"Frenchvel" has exceptional strength and durability. It withstands repeated erasures. The pure white, fine toothed surface takes pencil and ink beautifully. No leaching, no discoloring, no odor—even after long periods of storage.

Make no mistake—the tracing paper you use can be a great help or a hindrance. You can depend on "Frenchvel"—like any tracing medium in Bruning's complete line—to give you the best all-around performance. Mail the coupon below for your trial sheets of the paper you can see through—the paper that will see you through.

BRUNING

Offices in Principal U. S. Cities

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1800 Central Road, Mount Prospect, Ill.
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Please send me my free 8½"x11" trial sheets of improved, more translucent "Frenchvel" Tracing Paper.

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Company_____

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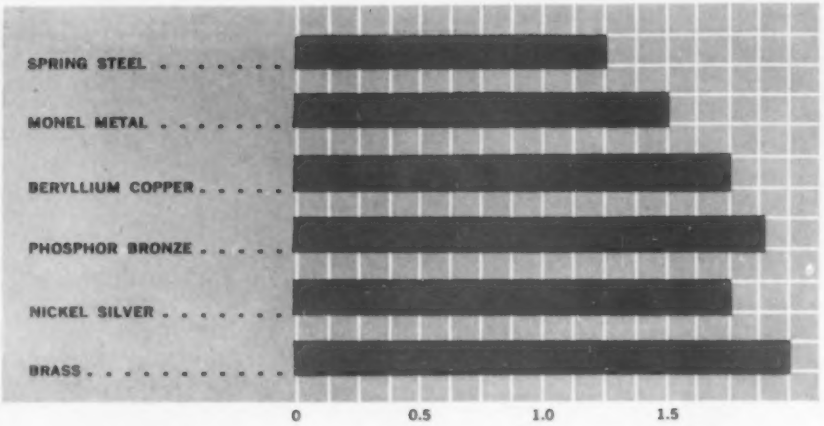

PER CENT DECREASE IN STIFFNESS WITH 100° F. INCREASE IN TEMPERATURE

How Temperature affects spring stiffness

When service or operating temperatures are above room temperature, spring selection must take into consideration several factors usually of little consequence in ordinary service.

These are loss of strength, thermal expansion, deflection, drift and hysteresis.

The first effect — loss of strength — is usually the most serious. What happens is that the safe stress carrying capacity of the spring material decreases at higher service temperatures and springs of ample strength at room temperature may be too highly stressed when heated.

These effects may be small in many cases, but under some conditions they may be important, particularly when temperatures vary over a wide range. Where an accurately determined spring strength at elevated temperature is desired, the specifications covering load test at room temperature should be corrected for the change that will occur. The approximate amount of correction for 100° F change in temperature for various materials is shown in the chart above.

With today's increasing high-temperature problems in many fields, proper spring selection is more than ever important. The subject is discussed in our latest pamphlet, "High Temperature Springs." Write for your copy.

Associated Spring Corporation

General Offices: Bristol, Connecticut

Wallace Barnes Division, Bristol, Conn. and Syracuse, N. Y.
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5811

Engineering problem:

Pressure-tight fastening of transit cases

The solution:

A specially modified LINK-LOCK

Applied Design Company engineers worked with Simmons to develop this successful LINK-LOCK application

Simmons LINK-LOCK, with design modifications developed in cooperation with the Engineering Department of Applied Design Company, Buffalo, New York, resolves special closure requirements in rigidly specified transit cases like the aluminum equipment container shown.

Here, the bowed LINK-LOCK engagement blade provides the double advantage of maintaining constant fastener pressure and permitting considerable mounting tolerance. This container is just one of many important products in which Applied Design specifies standard and special Simmons Fasteners.

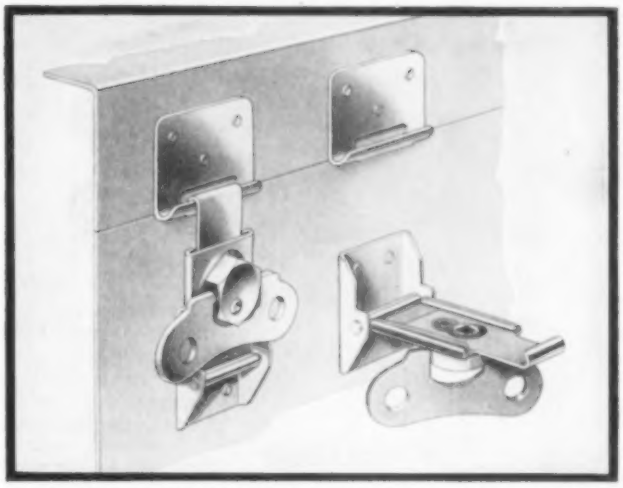
Here's why LINK-LOCK is ideal for use on military cases produced to exacting specifications as well as on inexpensive commercial containers:

- Impact and shock resistant (positive-locking).
- High closing pressure with light operating torque...insures pressure-tight seals where required.
- Available in 3 sizes, for heavy, medium, and light duty.
- Compact design...lies flat against case even when unlocked.
- Opening and closing by wing-nut, screwhead, or hex nut.
- Flexible engagement latch design...can be varied to suit different conditions.

Also available: Spring-Loaded LINK-LOCK. Ideal for the less expensive containers where costs won't permit precision production. Spring provides take-up to compensate for set in gasketing, irregularities of sealing surfaces, and mounting inaccuracies.

SEND TODAY for the Simmons Catalog for complete information and engineering data on LINK-LOCK and other Simmons Industrial Fasteners. Engineering service is available; outline your particular fastening problems. Samples on request.

Twelve special loop-blade LINK-LOCK fasteners are used in this aluminum transit case designed by Applied Design Company.



Standard No. 2 LINK-LOCK (Medium-Duty). Available with screwhead, wing-nut as shown, or hex nut.

SIMMONS

FASTENER CORPORATION

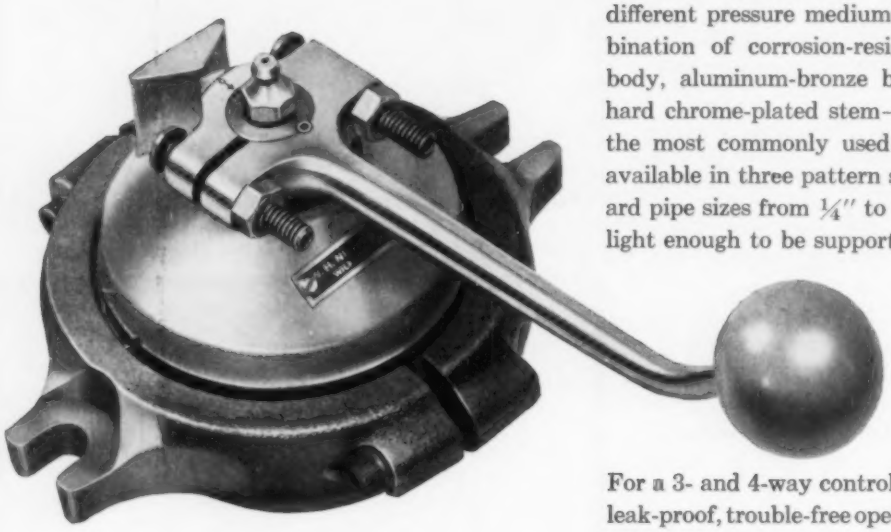
1751 North Broadway, Albany 1, New York

QUICK-LOCK • SPRING-LOCK • ROTO-LOCK • LINK-LOCK • DUAL-LOCK • HINGE-LOCK

See our 8 page catalog in Sweet's 1958 Product Design File

Here's a control valve that assures you

leak-proof service



Highly-lapped metal-to-metal surfaces of this Nicholson control valve assure you leak-proof service. The O-ring stem packing and O-ring seal between the body and base make joints leak-proof without excessive bolt tension.

You can use the Model 300 with air, water, hydraulic fluid or oil as the pressure medium . . . at operating pressures to 300 psi. Use it to activate single- or double-acting cylinders. Simple and rugged, this valve provides accurate, repeatable control of equipment such as presses, hoists, clutches and chucks. Valve maintenance is no problem . . . all stem, base and disc bearing surfaces are lubricated through one easily accessible fitting on top of valve stem. Lubricant reservoir in base reduces frequency of lubrication.

No need to stock valves or parts for service with different pressure mediums. This valve's *one* combination of corrosion-resistant materials—bronze body, aluminum-bronze base, stainless-steel disc, hard chrome-plated stem—is well suited for all of the most commonly used pressure mediums. It's available in three pattern sizes covering five standard pipe sizes from ¼" to 1" . . . small enough and light enough to be supported by connected piping.

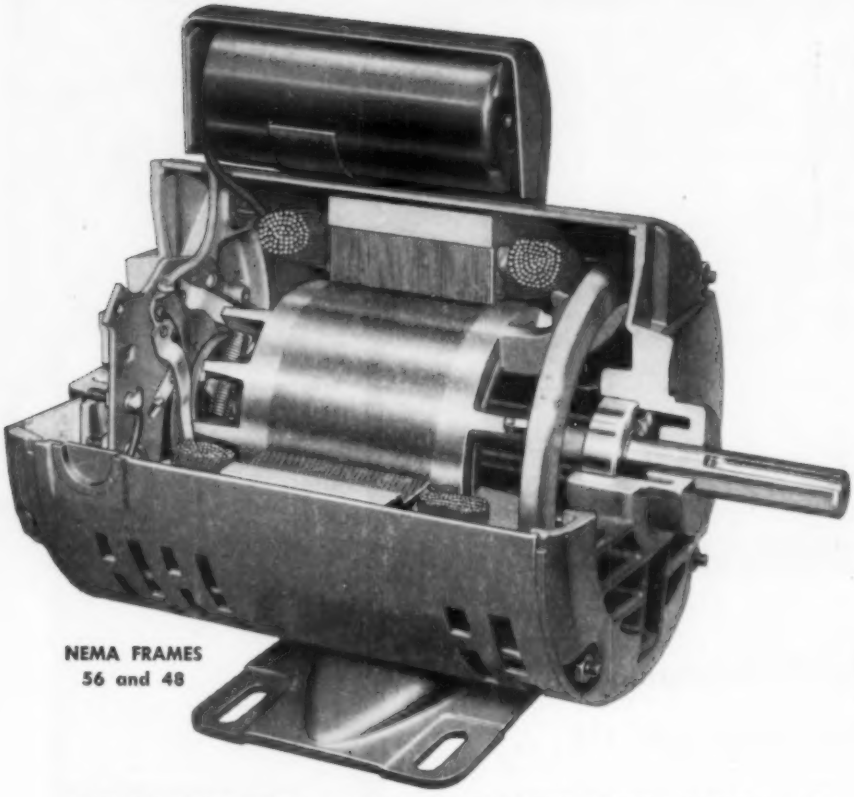
For a 3- and 4-way control valve that will give you leak-proof, trouble-free operation, specify Nicholson. W. H. NICHOLSON AND COMPANY, 14 OREGON ST., WILKES-BARRE, PA. Sales and Engineering Offices in 98 principal cities.

Write for Bulletin 300 . . . covering design, construction, sizes and applications for the Model 300

NICHOLSON

OF WILKES-BARRE

NEW R & M Fractional HP Re-Rated Motors



NEMA FRAMES
56 and 48

SPLIT PHASE

CAPACITOR START

PERMANENT
SPLIT CAPACITOR

POLYPHASE

MORE POWER...LESS WEIGHT AND SIZE!

Think of the advantages these new motors offer your products! Many new R&M Re-Rated Motors are less than half the weight of former designs. For example, the new R&M ¾ hp, 1725 RPM single phase motor weighs 26 pounds as compared to a former weight of 56 pounds. Performance, torque and overload service factors are well within national standards. Lightness and compactness have been accomplished by the selective use of lighter metals and more efficient double end ventilating.

Design versatility is an advantage too! R&M Re-Rated Motors in NEMA Frames 56 and 48 are available as complete "off the shelf" motors with a wide choice of mountings, bearings, mechanical and electrical characteristics in sizes from 1 to ⅛ hp. They're also available as motor parts without end heads. Write for Bulletin 450-PE.

Robbins & Myers build motors from 1/200 to 200 horsepower

OPEN AND TOTALLY ENCLOSED
SLEEVE OR BALL BEARINGS
RIGID, RESILIENT OR END MOUNTING
NEMA C FLANGE

SPECIAL PURPOSE MOTORS

Where production quantities justify, experienced R&M application engineers welcome the opportunity to furnish a design best suited to your particular power requirements.

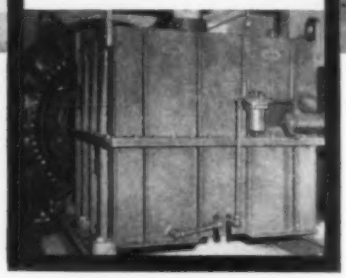
ROBBINS & MYERS, INC.

SPRINGFIELD, OHIO | BRANTFORD, ONTARIO

MOTORS FANS HOISTS MOYNO PUMPS INDUSTRIAL PROPELLAIR FANS

(Above) Cutting 64 inch spiral bevel gear on new precision gear generator.

(Below) Interior of rotor test stand showing Philadelphia Spiral Bevel Reducer. 1300 hp motor is in background.



Special 1300 hp Philadelphia Reducer drives helicopter rotor test rig...

Testing 90-foot helicopter rotors involved problems of torque and vibration, plus precise speed control and test rig maintenance. Kaman Aircraft Corp., Bloomfield, Conn., found the answer in a special spiral bevel Philadelphia Reducer driven by a 1300 hp variable speed DC motor.

This Philadelphia designed drive completely eliminated vibration and torque variation previously encountered in engine driven rigs. Maintenance is simpler. Precise speed control can be obtained at rotor speeds from 200 to 400 rpm.

For any right angle drive application, standard or special, Philadelphia Spiral Bevel-Helical Reducers will take more abuse and last longer under the most severe load conditions. One of the reasons is that all Philadelphia spiral bevel gears and pinions are heat treated and hardened *after* they are cut . . . then lapped to a mirror-like finish. Helical Gearing is precision hobbed on the newest, most modern equipment. The gear teeth are then crown shaved and induction hardened.

Result: better tooth contact, longer gear life. Units are vibration-free and quieter. On special applications, where conditions warrant, both spiral bevel and helical gearing can be furnished with precision ground teeth.

You can select a Philadelphia Spiral Bevel Reducer—or have one specially built—to suit your precise needs. Our Spiral-Bevel units provide ratios as low as 1 to 1, or as high as 238 to 1. Units are available in single, double or triple gear reductions—in both vertical and horizontal types. Catalog SB-57 describes them all. Write for your free copy today.

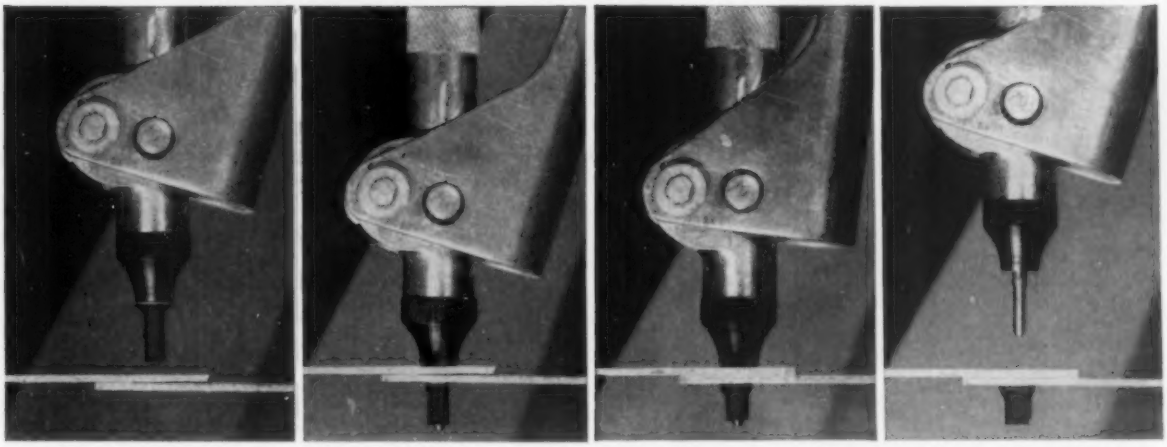
PHILADELPHIA GEAR CORPORATION
Erie Avenue and G Street • Philadelphia 34, Pennsylvania

philadelphia gear drives

Offices in all Principal Cities • Virginia Gear & Machine Corp., Lynchburg, Va.
INDUSTRIAL GEARS & SPEED REDUCERS • LIMITORQUE VALVE CONTROLS • FLUID MIXERS • FLEXIBLE COUPLINGS

B.F.Goodrich

Rivnuts® fasten thin metal... provide 6 threads in 6 seconds

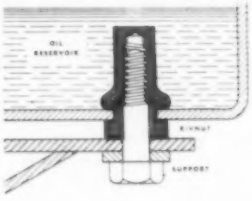


1 Rivnut is threaded onto pull-up stud of heading tool.

2 Rivnut is inserted—head held firmly against work.

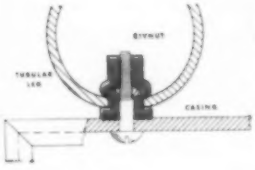
3 Tool lever operates pull-up stud, forms bulge in Rivnut.

4 After upset, Rivnut threads are ready for screw attachments.



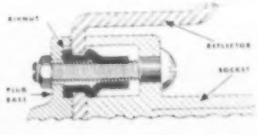
REPLACES BRAZED NUT PLATE

Rivnuts with closed ends are installed in one-tenth the time it took to braze nut plates on oil reservoir tanks. Leaking, warping and thread cleaning are eliminated, and spacer head assures proper positioning of tank on support bracket.



ELIMINATES NUTS AND BOLTS

One worker installs a Rivnut in the tubular leg of a portable barbecue in seconds—provides a firm, accurate nut plate for screw attachment. There are no boltheads to detract from the unit's clean lines. Time is saved, too, in faster knockdown for shipping.



DOES 2 FASTENING JOBS

Rivnuts provide 6-thread nut plate for attachment from either end—or both. In spotlight assembly, Rivnut replaces awkward welded stud for attaching socket. Plug base is attached on other side. Result: fewer operations, lower assembly cost.

B. F. Goodrich Rivnuts—the easy way to cut assembly time . . . costs

Rivnuts, the only one-piece blind fasteners with threads, can be installed by one person from one side of the work—in seconds. Easy installation saves up to 50% of assembly time, reduces production costs. Rivnuts can also improve the appearance of your products and make them easier to use and service.

Rivnuts are made in a variety of sizes and head styles to solve almost any fastening problem. They make tight, dependable seals that resist vibration, stay put so you can assemble and disassemble the product as often as you like without stripping the threads. Welding, tapping and thread cleaning are eliminated. And you can install Rivnuts after enameling without fear of chipping.

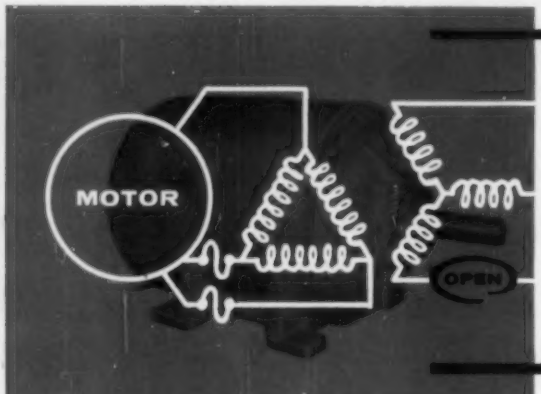
B.F.Goodrich Rivnuts have speeded up thousands of fastening jobs. They can do the same for you.

SEND NOW FOR FREE RIVNUT DEMONSTRATOR

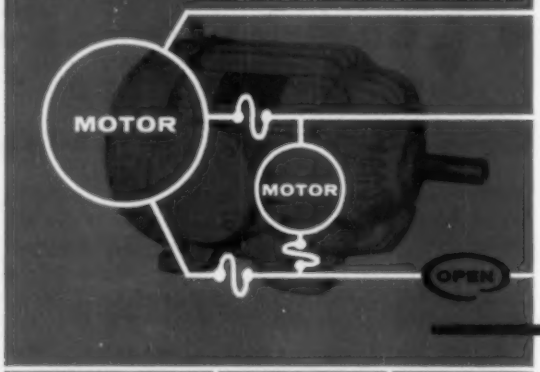
Demonstrates with motion how Rivnuts fasten *to* and *with*. Explains construction, gives proved applications. Write to B.F.Goodrich Aviation Products, a division of The B.F.Goodrich Company, Department PE-58, Akron, Ohio.

B.F.Goodrich aviation products

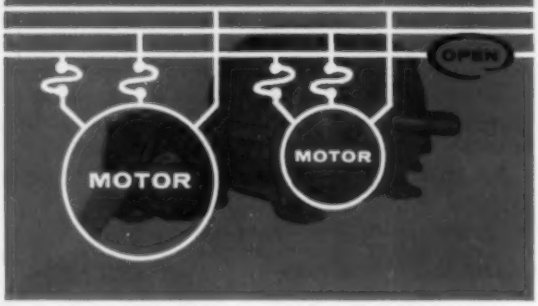
Three-Coil Overload Protection Would Have Prevented These Motor Burn-outs



MOTOR No. 1. Even though this three-phase motor was equipped with a 2-coil overload relay, the motor burned out . . . and here's why. Like the vast majority of three-phase motors in use today, this motor took its power from a wye-delta transformer; and an open phase condition in the transformer primary caused one high and two low motor currents. The 2-coil overload relay could not save this motor because the high current was in the unprotected line. Why gamble with a motor burn-out? Insist upon 3-coil overload relays for all your three-phase motors . . . the only dependable overload protection for all open phase conditions.

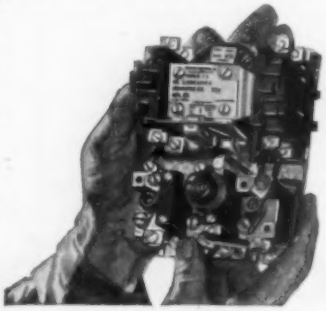


MOTOR No. 2. This three-phase motor was operating at 70% full load with a 40% loaded single phase motor connected in parallel when one of the incoming power lines opened. Once again the 2-coil overload relay failed to detect any trouble. However the motor current in the winding without a thermal element rose to 152% full load current, while the current in the phases with the 2-element relay did not reach tripping value. This caused permanent damage to the motor winding. This motor could have been saved with full three-phase overload protection. Be sure your three-phase motors are completely protected from the hazards of all open phase conditions with dependable 3-coil overload relays.



MOTOR No. 3. This 1 Hp, three-phase motor was working in parallel with a 10 Hp, three-phase motor when one of the incoming power lines opened. While the 10 Hp motor was not adversely affected by this circuit unbalance, the motor current in one line of the 1 Hp motor reached 140% full load current resulting in a burned out winding. As in the other examples, the 1 Hp motor's 2-coil overload relay proved ineffective because the overload occurred in the one line left unprotected. Don't let this happen to your motors. Insist upon 3-coil overload relays for every three-phase motor, large or small . . . only 3-coil overload relays provide dependable open phase protection under all operating conditions.

Cutler-Hammer Three-Star Motor Control offers 3-coil overload relays in all standard starter constructions and enclosures. For immediate delivery see your nearby Authorized Cutler-Hammer Distributor. Machine designers and panelbuilders, open type Cutler-Hammer Three-Star Motor Control with 3-coil overload relays require no more space than starters with only 2-coil overload relays. CUTLER-HAMMER Inc., 1332 St. Paul Ave., Milwaukee 1, Wis., *Associate:* Canadian Cutler-Hammer, Ltd., Toronto.



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MOTOR CONTROL
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BIG space-age problems get BIG flexible metal tube answers

Large-diameter flexible metal connectors in stainless steel and other alloys—to handle expansion and contraction, wide range of temperatures, corrosive fluids, high pressures, and vibration.

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Equipped to work in stainless steel, Monel, and aluminum as well as in other alloy steels and copper alloys, these Anaconda specialists welcome the opportunity to help you get the flexible metal hose you need to meet your problems of expansion and contraction, movement, vibration, corrosion, pressures, and temperatures.

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Please send me your free, 60-page General Catalog containing basic information on all types of metal hose and tubing, fittings, etc.

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High Speed . . . Electric Eye
. . . "Pulse Stretcher"
. . . Instant Reset

First of a new series of electric and electronic counting "packages" is this Model C "Count-Pak" . . . consisting of the new V-R instant-reset, high-speed (3,000 counts per minute) electric counter combined with a light source and photo cell.

Cell and light source can be adapted to any application . . . and are permanently assembled so vibration can't jar them out of focus. Pulses as short as .0002 seconds will actuate this device, which means that a ¼" object or space moving at 6,000 feet per minute will be counted. "Count-Pak" is transistorized throughout (no tubes) and utilizes printed circuits . . . double assurance of instant action and long trouble-free life. Rugged, compact case: 8¼" wide; 5¼" high; 6¼" deep. Panel includes pilot light, reset button, and power switch. *And prices are unexpectedly low.* Write:

*Trade-mark registration applied for.

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Impregnated fabric produced by Technical Rubber, Inc., West Haven, Connecticut

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A suitable fabric has been developed by coating nylon with many thin applications of a special Neoprene/THIOKOL plasticizer TP-90B compound. Aside from providing the necessary high pressure and low temperature properties, THIOKOL plasticizer acts as an inhibitor against fungus which often causes fabric deterioration in tropical climates.

THIOKOL plasticizer TP-90B is also an ideal low temperature plasticizer for acrylonitrile rubbers, SBR rubber and natural rubber. It provides excellent low temperature properties and has low volatility.

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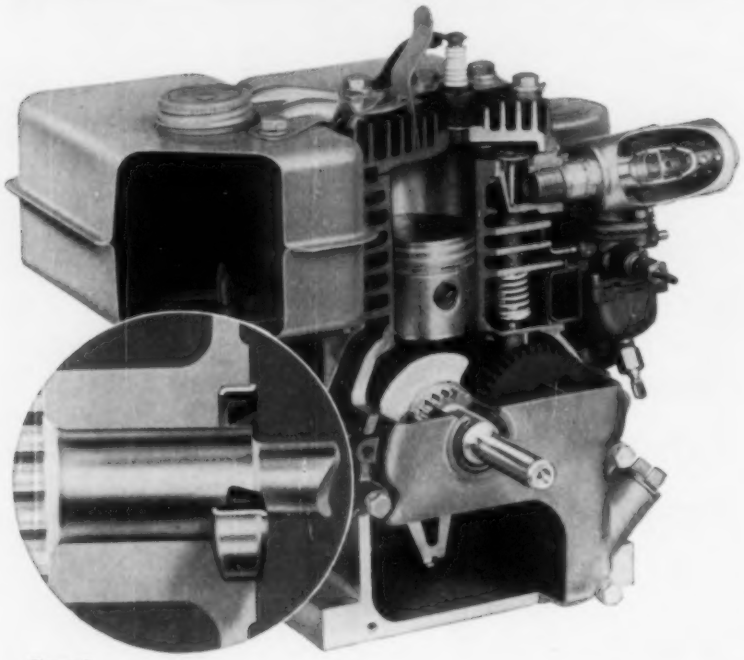

Figure 1.

Zero leakage oil sealing a "must" in Briggs & Stratton 2¾ hp engine

Some oil sealing applications can accept a small amount of lubricant leakage or "seepage." But not the Briggs & Stratton 8B Engine. Here, on a ⅞" crankshaft turning up to 3,600 RPM, light engine oil must be positively sealed in the crankcase at both front and rear bearing points. Oil temperature is 200° F with the engine at wide open throttle; and external temperatures may range from —30° to 125° F. Many Briggs & Stratton 8B engines operate only after long periods of inactivity; others are used continuously, a variable which makes the sealing problem even more demanding.

Satisfactory sealing and long, trouble-free service life is obtained by use of two special National Syntech® synthetic rubber seals (Fig. 1)—one at either sealing point. These precision made Syntechs have a minimum-contact sealing lip seating lightly but firmly on the shaft. The steel outer case is a precise press-fit for the bore, simplifying installation and preventing accidental working free of the seal.

National pioneered Syntech synthetic rubber seals; today offers a complete line of Syntech and leather seals plus convenient, competent oil seal engineering assistance. For data, for practical design help, call the National Seal engineer. He's under Oil Seals, in the Yellow Pages.

Variations on basic oil seal designs

10,000-S

Many modifications of the basic National spring-loaded Syntech oil seal design are offered. For example, where external conditions require a felt dust baffle, National 10,000-S may be employed. Where dirt or grit conditions are severe, a National 20,000-S with leather or Syntech auxiliary sealing lip is often used.

230,000-S

For applications where shaft entry is made from the auxiliary side, a National 230,000-S seal with auxiliary leather washer-type sealing lip mounted *in tandem* is suggested.

70,000-S

For positive separation of low viscosity fluids at higher speeds and temperatures, National 70,000-S series seals are suggested. Basically two 50,000-S seals mounted with sealing lips opposed, this seal may be used at temperatures above 250° F and speeds in excess of 2,000 FPM.

Altogether, National offers over 2,500 basic types and sizes. There is one best seal for a given application. Your National engineer can help you obtain it.

NATIONAL SEAL

Division, Federal-Mogul-Bower Bearings, Inc.
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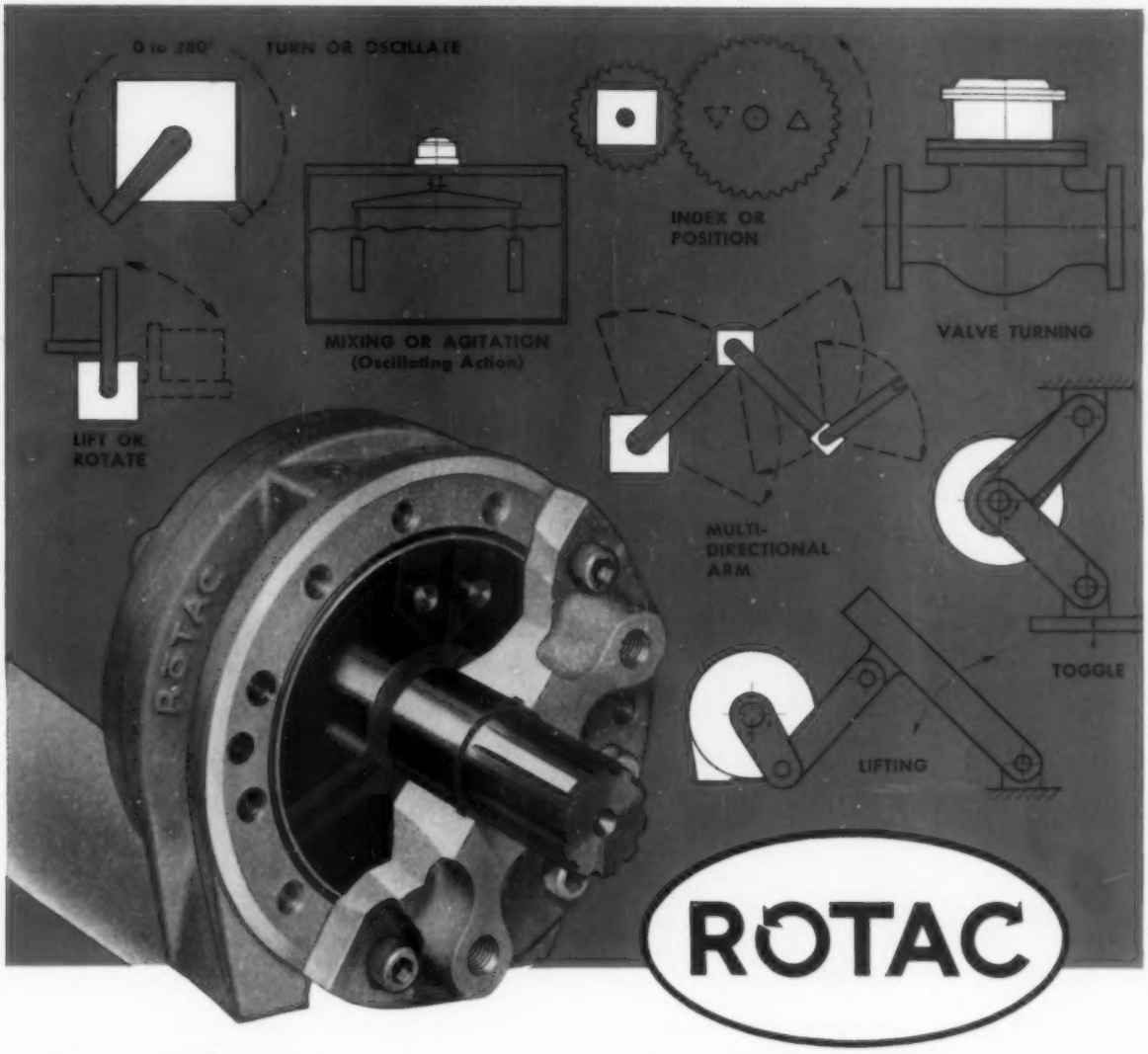

Limitless as your imagination...

Rōtac reciprocating torque actuators provide a positive control for any movement from turning watch parts to tipping railroad cars

Just imagine the virtually limitless applications now easily and economically practicable with Ex-Cell-O precision reciprocating torque actuators. Trademarked Rōtac, these actuators transmit maximum torque per displacement in a vast variety of operations: clamping, indexing, lifting, lowering, revolving, pushing, pulling, opening, closing, swinging, oscillating and turning. Into each Rōtac actuator goes the traditional excellence in design, development and manufacture you have come to expect over the years in every Ex-Cell-O-built product.

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If you move *anything*, then you'll want detailed information on Rōtac. Learn how this rotary power is used throughout industry in thousands of applications. Complete with photos, schematics, engineering data, etc.

57-60

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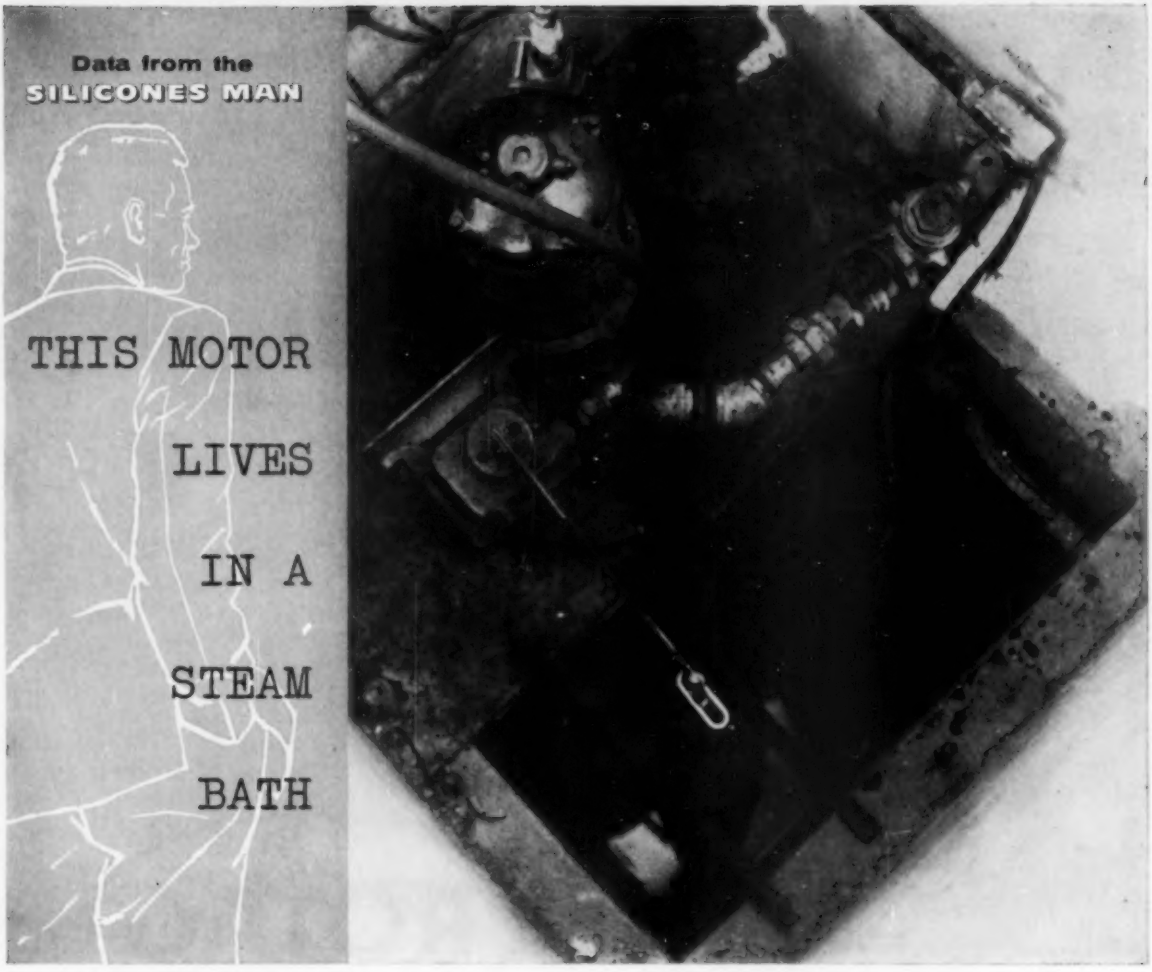
EX-CELL-O PRECISION PRODUCTS INCLUDE: MACHINE TOOLS • GRINDING AND BORING SPINDLES • CUTTING TOOLS • RAILROAD PINS AND BUSHINGS • DRILL JIG BUSHINGS • AIRCRAFT AND MISCELLANEOUS PRODUCTION PARTS • DAIRY EQUIPMENT



When water accumulates in an underground steam distribution system this pump goes to work. But during periods of heavy rain, the water rises and covers the pipes, giving off clouds of steam. Failures were frequent. Since rewinding to Class H specifications using UNION CARBIDE R-620 Silicone Insulating Resin, there has not been a single failure! Time and time again, where a motor is subjected to high temperatures, corrosion, overloads, or dirt, the answer has been found in Class H insulation.

You can easily give your rewind customers all the advantages of Class H insulation, because R-620 Silicone Insulating Varnish is as simple to use as ordinary varnishes. For example, at 450 deg. F., a Class H motor would cure in less time than a Class B motor of the same size at 300 deg. F. The time consuming step-by-step curing cycles required by earlier materials are eliminated.

UNION CARBIDE R-620 is easily adapted to your shop practice. You will find that it gives a hard, tough, yet flexible finish. The proper viscosity is built in, eliminating frequent solvent additions. No additional treatments are required to protect against moisture or corrosive atmospheres.

Find out more. Write for the booklets, "UNION CARBIDE Silicones for Dependable Service" and "More for your Silicones Dollar." Address Silicones Division, Dept. P-54, Union Carbide Corporation, 30 East 42nd Street, New York 17, N. Y.

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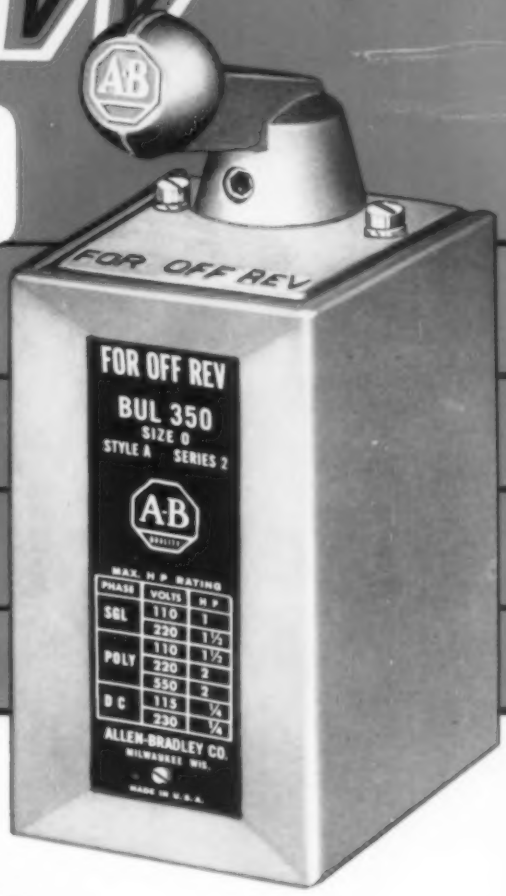
new

BULLETIN 350 reversing drum switch



Styled by Brooks Stevens, internationally famous industrial designer.

- *MODERN IN APPEARANCE*
- *AVAILABLE AS OILTIGHT—FOR CAVITY MOUNTING*
- *EASY TO MOUNT*
- *EASIER TO WIRE*
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A-B QUALITY

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In Canada—Allen-Bradley Canada Ltd., Galt, Ont.

6-58-MR

A new "quality" standard for small REVERSING DRUM SWITCHES

A-B QUALITY

GOOD-LOOKING AND GOOD "FEELING" DIE CAST HANDLE

EASILY ACCESSIBLE MOUNTING HOLES

MERELY LOOSEN SCREW AND SLIDE PLATE to change from momentary to maintained contacts —or vice versa

INDEPENDENT SWITCH MOUNTING prevents misalignment

HEAVY CONTACT SURFACES for long operating life

TWO CONDUIT OPENINGS

WRAP-AROUND COVER gives complete access to drum

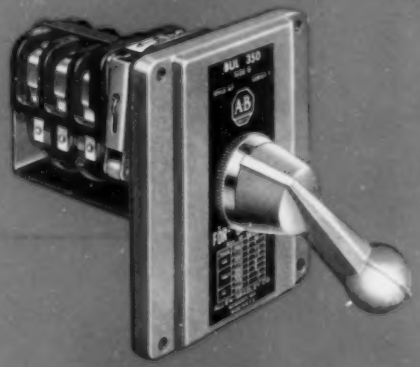
SINGLE SCREW COVER MOUNTING —screw cannot fall out

ACCESSIBLE SCREW TERMINALS for front wiring

RAISED EDGE for base mounting without spacers

maximum rating 2 horsepower

NEW OILTIGHT COVER PLATE FOR CAVITY MOUNTING



Bulletin 350 Reversing Switch can be furnished with oiltight cover plate with rubber gasket seal for cavity mounting in a machine base.

This *all-new* Allen-Bradley reversing drum switch was designed to keep pace with the mechanical beauty designed into so many of the modern machine tools.

The Bulletin 350 reversing switch is equivalent to a three-pole, double throw switch . . . and can be used with d-c motors; or single phase, two phase, or three phase a-c motors.

Investigate the Bulletin 350 . . . the *new leader* of its class . . . in appearance, ease of installation, and operating life. An Allen-Bradley *quality* switch . . . in every sense of the word. Send for descriptive bulletin.

ALLEN-BRADLEY

MOTOR CONTROL

QUALITY

Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wis.
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Pay less for more strength! Tenzaloy the self-aging aluminum alloy needs no heat treatment! If your aluminum castings are too large or too intricate for heat treatment, if your heat treating facilities are limited, if you need superior strength than you get from ordinary heat-treated alloy demand "Federated Tenzaloy" developed by Federated to meet the need for a superior aluminum alloy that ages at room temperature. Tenzaloy eliminates rejects due to warpage, expansion, and internal stresses caused by quenching. Tenzaloy finished properties are stable, proved by conclusive test data over a ten year period. No special foundry techniques are required. No fluxes. Castability is excellent with sand cast and plaster molds and many permanent molds. Tenzaloy will not "grow," produces corrosion-resistant castings with excellent polishing characteristics and anodizes clear white. Write for Tenzaloy Bulletin No. 103. Federated Metals Division, 120 Broadway, New York 5. In Canada: Federated Metals Canada, Ltd., Toronto and Montreal.

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TENZALOY is one of a complete series of Federated aluminum casting alloys. A new plant in Alton, Ill. will soon be in production to satisfy the requirements for Tenzaloy in the mid-west.

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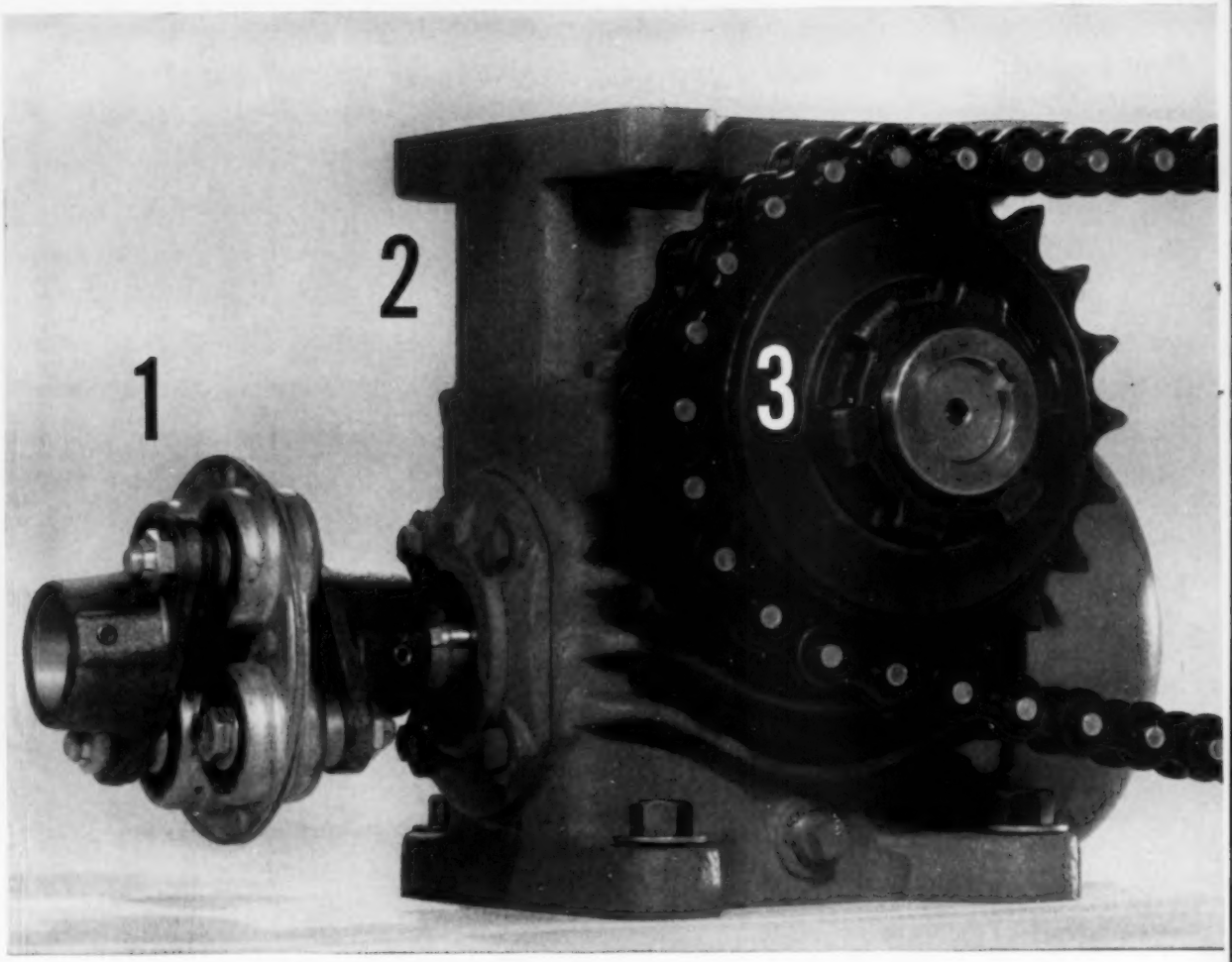

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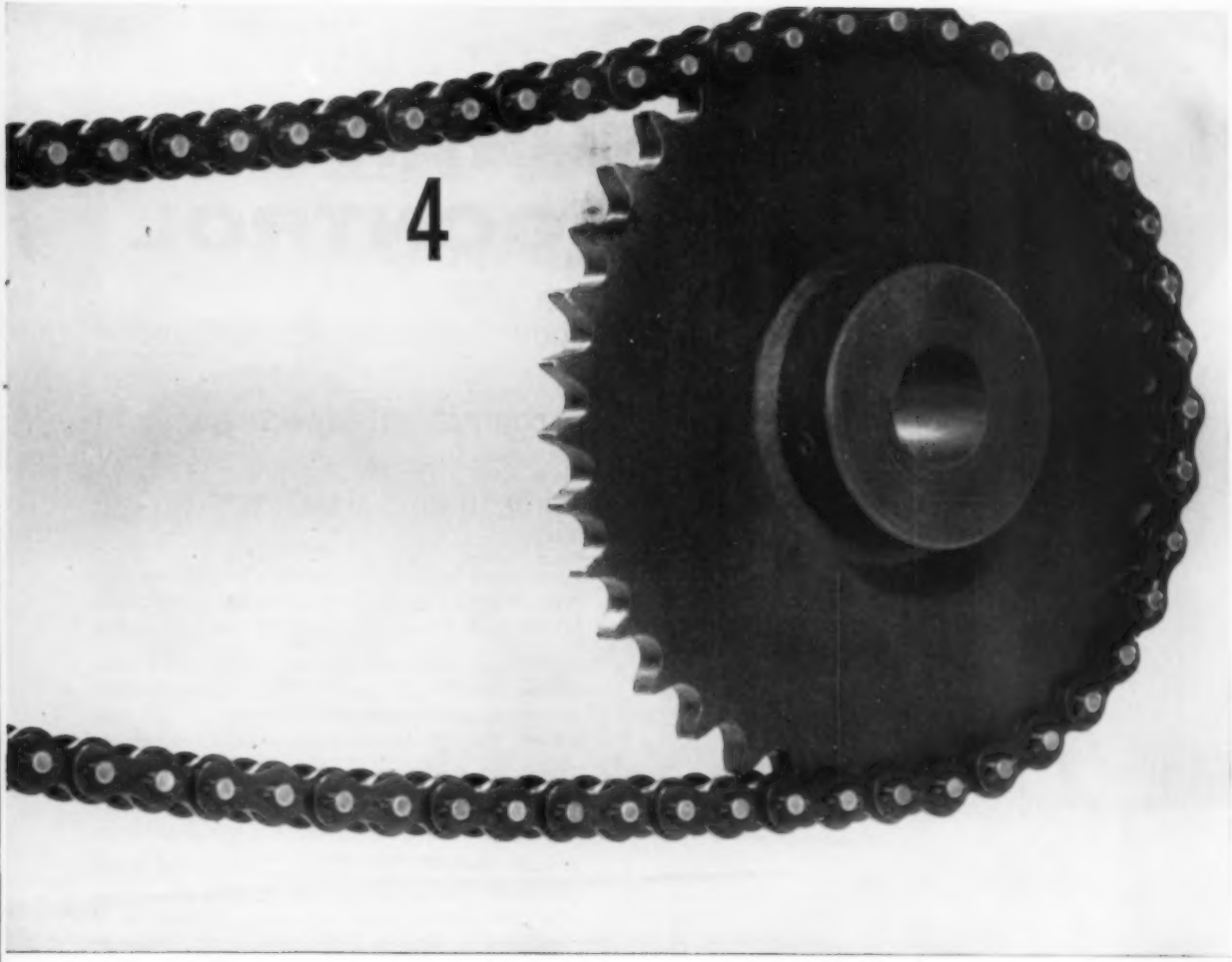

power transmission needs because only Morse offers transmission components

REMEMBER: The toughest jobs in power transmission come to Morse, because *only Morse* offers one-source service on all four of these basic components . . . and backs them up with technical know-how based on over 60 years' experience solving power transmission problems.

IN POWER TRANSMISSION THE TOUGH JOBS COME TO

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MULTI-RANGE FLOW CONTROL

- extra-sensitive flow control adjustment...for precise flow settings
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- available for the first time in all 3 sizes...¼"—⅜"—¾"

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With the new Denison Multi-Range Flow Control in your design system, you can count on these important advantages and features . . . all pioneered through Denison advanced engineering:

- **PRECISE FLOW SELECTION** . . . is made possible through a new extra-sensitive control with an exceptionally wide span of adjustment in any given range.
- **MULTI-RANGE CONTROL** . . . allows one model to do the work of many—also simplifies your inventory. Adjustment from one range to another is guarded by stops to afford safe, simple, foolproof operation.
- **UNIFORM RATE OF FLOW** is assured because Multi-Range Flow Control is virtually free from flow change due to temperature-viscosity changes.
- **SURGE OVERTRAVEL VIRTUALLY ELIMINATED** —by simple adjustment—to avoid erratic feed of slides as the valve finds its setting.
- **BUILT-IN RELIEF VALVE** saves space and cost of additional piping.
- **BUILT-IN CHECK VALVE** permits reverse free flow.
- **REQUIRES NO EXTERNAL DRAIN.**
- **PRODUCTION PRICED** . . . and built to JIC Standards for operating pressures to 2000 psi.

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Write for Bulletin VFC-3.

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Heavy-duty parts
Making epoxies flame-resistant
Metallized phenolics

Chrysler Corporation

Rugged

Got a job that's "too tough for phenolics"?

You might never think of phenolic for a part like this Chrysler-engineered automotive oil-pump gear—subject to wear, heat, friction, constant oil immersion.

But you'd be reckoning without the ruggedness of a new phenolic, *Durez 16771*.

Parts molded from this glass-fiber-filled compound have a flexural strength of 20,000 psi, compressive strength of 16,500 psi. Their tensile strength is 7,000 psi. Modulus of elasticity in tension is 3.0×10^6 psi. What's more, the heat distortion point of these parts is up around 600° F.

Payoff • These properties, plus excellent resistance to oil, water, and acid, made Durez 16771 appear to have some of the properties needed for the Chrysler oil-pump gear. After extensive experimenting and testing, Chrysler engineers developed the plastic gear to replace the usual metal part.

Results: *new gears of Durez 16771 outwear metal gears nearly 3 to 1—show no performance-affecting wear after 200,000 miles; save about two-thirds of the cost of metal gears; run more quietly.*

For a data sheet describing this high-strength phenolic, check opposite "16771" on the coupon.

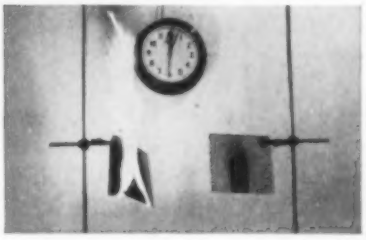
How to make epoxies resist flame

Your epoxy laminates and castings will shrug off heat, moisture—even fire—if you cure them with a new Durez product called HET® Anhydride.

In the picture that follows, the laminate cured with a conventional hardener ignites in less than 30 seconds and burns to destruction in about 3 minutes. Exposed to a similar flame source for the same time, a HET-cured laminate snuffs itself out as soon as the flame source is removed.

This leads to some interesting possibilities. For instance, you can now make glass-reinforced laminates that keep practically all their flexural strength, *even when heated within the 300-350° F range.*

You can make potting resins that retain room-temperature electrical properties at high humidities *and at temperatures above 300° F*—and won't feed a fire.



For easier casting or wet layup, you need not handle HET Anhydride hot. You can mix it with another anhydride to form a curing system that *stays liquid at room temperature.* Toxicity is very low.

If you'd like complete information on HET Anhydride, methods of use, and properties of cured resins, check the coupon for Bulletins 19 and 43.

Bright idea

Next time you want to put a bright reflective surface on a part, think of *metallized phenolic.* It may save you a costly production step.

American Optical Company

For instance, this housing for a microscope lamp requires a mirror to focus the light.

To sidestep the cost of a custom-made mirror, the housing is molded of Durez phenolic. Then an aluminum mirror is deposited right on the plastic by vacuum evaporation.

This is easy to do with the Durez compound chosen for this part. It provides a good hard surface for metallizing. It incorporates other wanted properties: high impact strength and low thermal conductivity.

You're on sure ground when you base bright ideas like this on phenolics. They give you a bigger choice of controlled properties than any other material in their class. You can select the right balance from *more than 150 Durez compounds.*

To take a fresh look at today's phenolics, just check the coupon for a new four-page bulletin describing some typical Durez molding compounds and what you can do with them.

For more information on Durez materials mentioned above, check here:

- ☐ High-impact Durez 16771
- ☐ HET Anhydride—Bulletins 19 and 43
- ☐ Phenolic molding compounds—descriptive bulletin

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DUREZ® HOOKER CHEMICALS PLASTICS

PLASTICS DIVISION
HOOKER ELECTROCHEMICAL COMPANY
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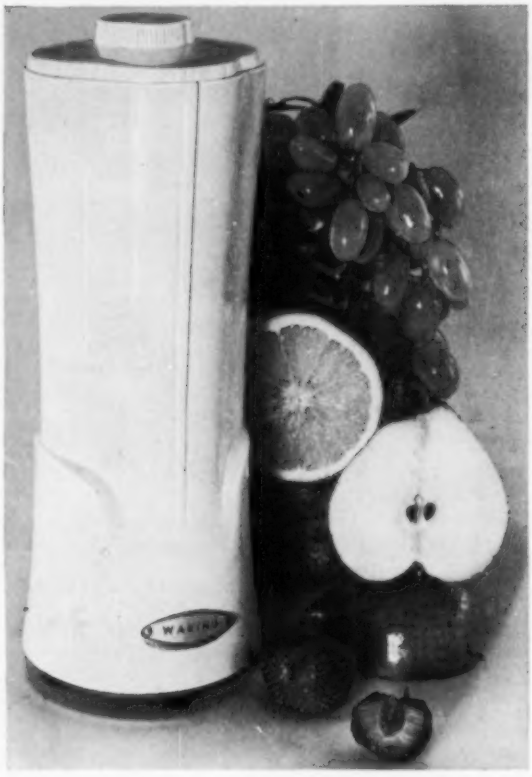
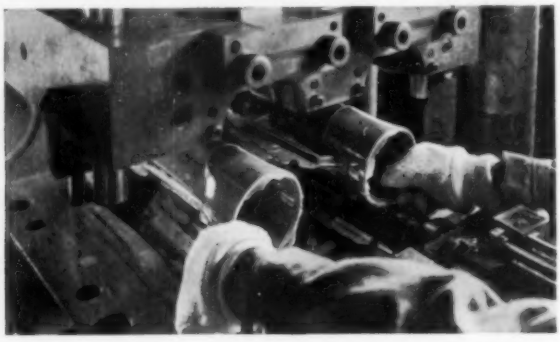
CYANAMID

PLASTICS IN ELECTRICAL DESIGN

Drink Mixer and Server...One Graceful Molding of CYMEL®



Conceived as both mixer and server of beverages and sauces, the new Waring Drink Mixer serves graciously anywhere in the home. In accord with the need for style, portability and economy, the mixing cavity, motor housing, handle and pouring spout are molded in one unit of CYMEL 1077 melamine molding compound—familiar to consumers in popular MELMAC® dinnerware. This styling in CYMEL keeps down size, weight, and cost. CYMEL provides insulation, strength, resistance to heat and staining, excellent stability, low moisture absorption, permanent rich molded-in color and hard surface.



Two complete one-piece mixer bodies are molded of CYMEL in each cycle. Mixing cavities and motor housings are formed by cores. Here, mold is open, motor housing cores have been automatically retracted, and the two mixers are being manually removed from top-cavity cores. Molder is Shaw Insulator Company.

CYMAC® Window on Circuit Breaker Contacts

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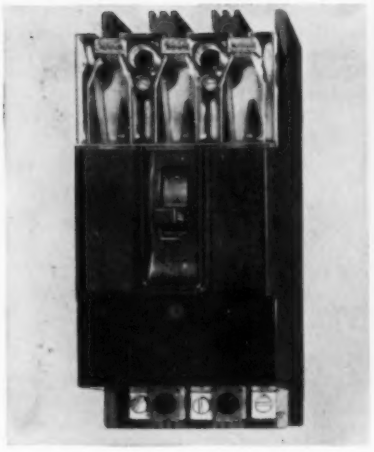

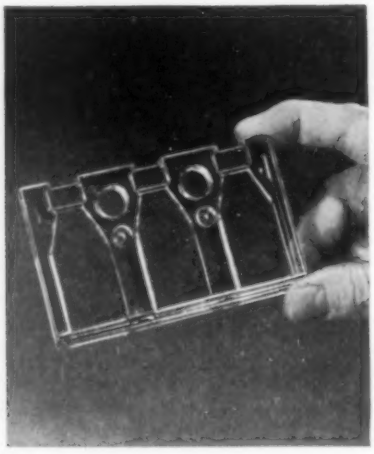

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PERSPECTIVES

in design and development . . .

Licensing Road to Foreign Markets

Foreign licensing agreements, which have been called a middle-of-the-road approach to foreign markets, have grown substantially since World War II. Many companies who had no licensing experience prior to 1945, have since then added agreements at the rate of three or more a year.

In a recent survey the National Industrial Conference Board covered 131 US and Canadian firms. It found some 60% were satisfied with their experience in this field and considered it an effective way to develop foreign markets. Another 30% approved of licensing under certain conditions, and the remaining 10% were generally opposed to licensing, or regarded it an unsatisfactory way to develop foreign markets.

Called the middle approach to foreign markets—an alternative between exporting and direct investment abroad— a substantial proportion of existing licensing agreements, the NICB says, were entered into without carefully considering other approaches to foreign markets. Nor was much thought given to how far these agreements would go towards fulfilling the long-range objectives of a company.

"In fact," the NICB points out, "most companies have never attempted to set long-range trade objectives. A foreign concern asks for a license; the potential income seems attractive; and a deal is consummated. Furthermore, once an agreement is negotiated, top management is inclined to forget it until the time comes to renew it, or the licensee decides to ignore it and go off on his own."

Actually, no one knows the full extent of foreign licensing today. There does not seem to be any comprehensive data on either the number of US companies with licensing agreements, or the total number of agreements in force. There are not even reliable estimates of the total royalties and other income received from such licensing arrangements. Estimates have placed the number of agreements in the thousands and the gross royalties at around $500 million a year.

Of the 500 foreign licenses of these companies participating in the survey: 50.6% of the licensees are located in Europe and the United Kingdom; 17.4% are in Latin America; 12.2% are in Asia; 9.0% are in Australia and New Zealand; 6.2% are in Canada; and 4.6% are in Africa.

R&D Gets Financed

Many of the companies with foreign licensing agreements used their income primarily to help underwrite the increasing costs of their domestic R & D programs. By broadening the market for their products abroad, they reduce the unit cost of research and new product development.

The most common use of foreign licensing is to get around the trade and foreign exchange barriers that hold up the free flow of exports from the US. A market area may be cut off by the withdrawal of an import quota or an embargo on dollar exchange, or by protective tariffs. But even if there are tariffs or trade barriers, US manufacturers may be at a competitive disadvantage in a foreign market because of production and transportation costs. To overcome such disadvantages, US companies may find it desirable to manufacture abroad. Justification for such action was given recently by the president of the National Machine Tool Builders Association who said that tariffs on machine tool imports were too low and tariffs and fees of foreign countries were too high. He said that US tariffs on imports ranged from 15 to 20%, while some foreign countries had imposed fees and tariffs of about 55% on US exports.

—Paul Anderson

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Product Engineering **HORIZONS**

May 26, 1958

The Return of Derring-Do

When the pilgrims settled this country, they started a new fashion in heroes. Until then the most admired men had been the swashbucklers—the warriors, the Vikings, the Crusaders. Even years later, Europe made much of Napoleon, the pirates, the explorers. Americans had their Dan'l Boone and Kit Carson, but the symbol of courage was changing to financial daring rather than battles with an implacable nature. We developed a new kind of swashbuckler, the magnate who took chances with money—on furs, railroads, timber, oil, steel. He risked few lives, but he did risk futures, and history remembers him for the risk as much as the gain.

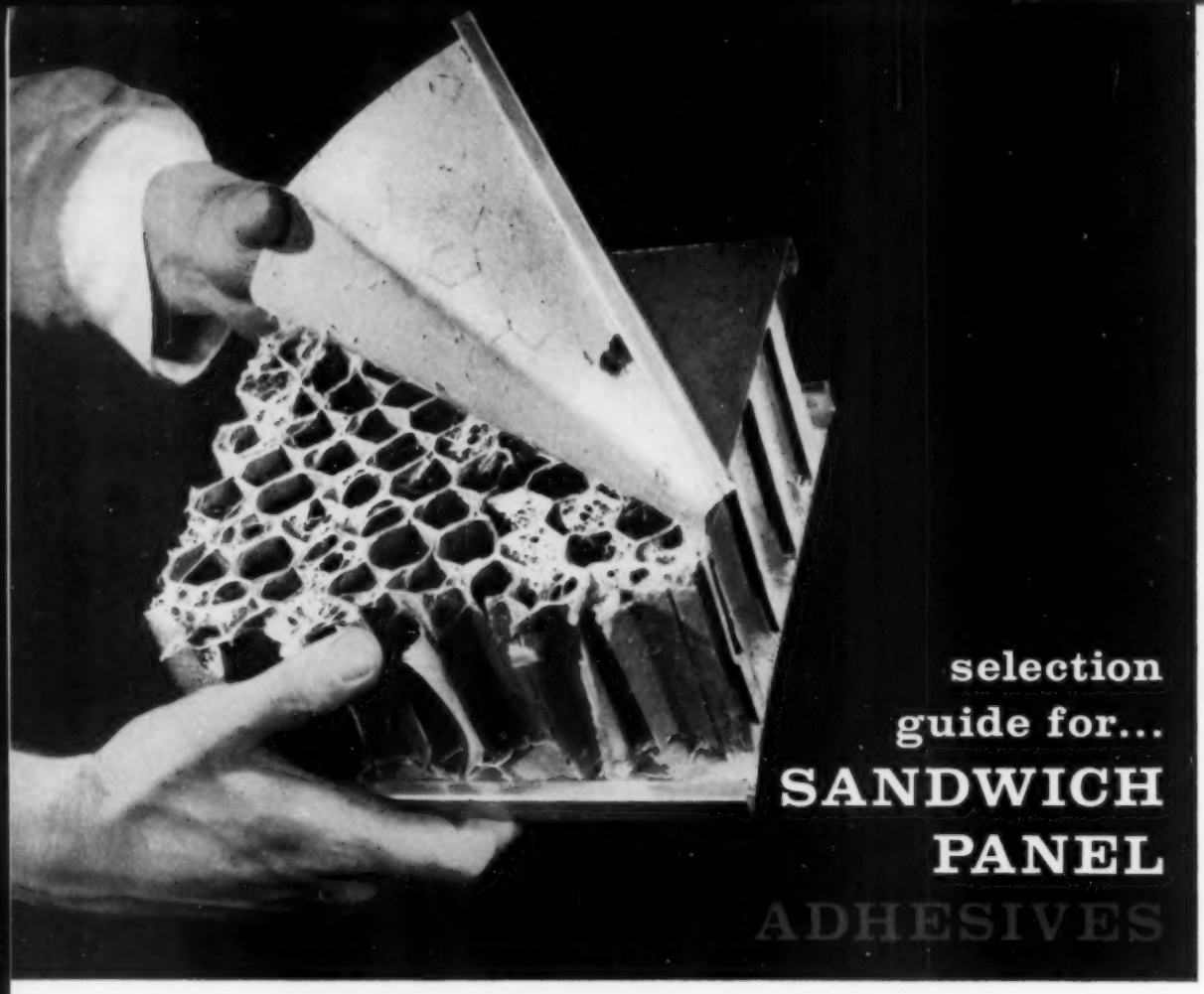
But a ground swell of admiration for the conservative was moving in. Finally, with the 1929 depression, with Government regulation, taxes, corporate management and lack of general security, conservatism took over. Bigger and bigger companies and combines merged to share and shift the risk rather than extend it. Even smaller companies became staid and cautious so Uncle Sam and the stockholders would find nothing to complain about.

Our young men, traditionally the foolhardy sparkplugs, now choose security and fringe benefits rather than small business. They marry earlier, go into debt for homes, cars and appliances, and become fully responsible family men at an age when their fathers were still sowing wild oats.

This period seems, however, to be passing. Perhaps the sputniks were the final straw. But in sharp contrast to the general caution exhibited by most people and evidenced by the current recession, we have some individuals and companies striking out boldly in new directions. Some are in astronautics and speak boldly of the space age to come. Some are trying radically new products or new fields. The lethargy and content that characterized the "good times" of the last 20 years are giving way to aggressiveness and new ideas again.

It is high time that this should happen. No country progresses without some of the spirit of derring-do, some of the wilingness to damn the torpedoes. We in America have tended to assume that "things will always be this way," tended to live on past glories, on past achievements, tended to refine and perfect rather than originate.

We need to reawaken some of the Pike's-Peak-or-bust, all-or-nothing, do-or-die attitude. Without some people willing to shoot the works, we are destined for national senility.



selection guide for... SANDWICH PANEL ADHESIVES

In this article concluding a 3-part series on sandwich materials, the 14 most widely specified adhesives are described and compared. First article (PE—Jan. 20, p. 70) covered cores; the second, (PE—Apr. 28, p. 80) compared facing materials.

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The many adhesives now available for holding together a sandwich panel have paid off in product improvement. In wetting behavior and bond reliability they have kept pace as sandwich construction has advanced to prove itself under widely different environments of heat, cold, impact loads, fatigue, corrosion. But the wide choice has complicated the job of selecting the adhesive best for a specific application. Here is an orderly approach to the problem—the most common adhesives for such construction are discussed in detail below, and in the accompanying table properties of the main types are compared at a glance.

There are other methods for fastening facings to core, notably brazing and welding, but adhesives offer these advantages:

- **As a barrier film,** they reduce corrosion between core and skin of dissimilar materials.
- **As an energy absorber,** they help damp out vibrations and reduce the probability of fatigue failure.
- **As chemical formulations,** they can be tailored to the requirements of load, material, environment, and production method.

Obviously, there can be no single, all-purpose adhesive. Most of them are formulated for balance of properties plus emphasis on certain features. Another guiding principle: the adhesive need be no stronger than the weaker of the two structural components of the sandwich—core and facing.

Based on these points, the selection problem breaks down into this four-step series of considerations:

- **Materials being bonded.** The adhesive must wet and adhere to both core and facing without causing deterioration or deformation.
- **Job requirements.** Peel, shear, tensile and cleavage-strength requirements should be compared and weighed, with some knowledge of ASTM test procedures. Also, adhesives vary in their capacity to withstand weather, moisture, chemicals, temperature extremes, impact loads and fatigue.
- **Panel assembly method.** Some adhesives need cur-

ing with elaborate equipment for best properties—thus time cycles, temperatures, and pressures become important for economical production. Sometimes the method chosen may require purchase of new equipment or modification of old machines.

• **Adhesive cost.** One consideration is the amount of adhesive in the panel; another is the estimated waste, and rejects. Adhesives differ in time required for preparation and application. The method chosen may not only dictate new or revamped equipment, but also additional personnel for panel inspection—an added cost burden.

These four steps apply, regardless which adhesive category is under consideration. As the table shows, there are three such subdivisions: rigid, high-strength (thermosetting); semirigid, medium-strength (thermosetting-thermoplastic combined); and flexible, low-strength (thermoplastic). But the right adhesive type can seldom be selected from such a comparison alone—the categories overlap, there are many formulations within each that are not shown, and the different types are often subtly combined to solve tough problems. The general rule is: know the general characteristics of the many kinds, but don't be your own adhesives expert.

THERMOSETTING ADHESIVES

Strength, rigidity and durability in the thermosets are properties that result from chemical curing—initiated in the base resin by a catalyst, by heat and pressure, or by a combination of these. The strongest of all sandwich panel adhesives, thermosets are more difficult to apply because of the controls needed to complete the reaction. Catalyst-activated thermosets, called two-part systems, are available as sprayable or brushable liquids. One-part systems, activated by external heat, are in the form of buttery pastes or the new solid films—either supported or unsupported. Although many thermosets can be cured at room temperature, best properties are obtained with heat and pressure—squeezing the sandwich laminate during cure flows the adhesive and wets the surfaces uniformly.

Epoxies are noted for high shear strength, rigidity, excellent self-filleting, and good wetting. Volatiles are not given off during cure, either in catalyst-activated, room-temperature, one-part formulations, or those one-part systems cured by heat and pressure. Self-filleting, or beading, is extremely important in honeycomb sandwich: the bead that clings to the edge of each cell flows into a firm double fillet when the facing is pressed in place—adding more bond area and strengthening the structure.

Good for temperature extremes, some epoxies will now take over 1000 psi in shear for extended periods above 450 F; others will go down to −67 F with shear strengths to 5000 psi. Ultralow temperatures—in liquid nitrogen, for example—embrittle any adhesive, epoxies included. In fact, some aircraft companies are now salvaging reject panels by immersing them in liquid nitrogen and parting the adhesive with several sharp blows.

Best high-temperature-resisting epoxies are the one-part heat-cured types. Room-temperature curing with amine activators gives bonds limited to about 150 F, though post-curing to 200 F will boost the fall-off temperature to about 180 F. Chief disadvantages of epoxies are low peel strength, low flexibility and thus poor impact strength, possibility of skin irritation, and high cost. For closed structures like honeycomb-cored panels, however, the advantages—particularly self-filleting and absence of volatiles that might require venting—make them economical.

Resorcinol and phenol-resorcinol adhesives are well known as high-strength, water-resistant adhesives for bonding wood panel structures and wood facings to paper honeycomb cores. Plastic skins of nylon, cellulose acetate, urea, acrylic and phenolic resins are commonly bonded to wood cores with two-part resorcinols, which develop best properties after about 6 days curing at room temperature. This can be cut to three minutes press time if the bond is cured at about 180 F. For metal bonding, an elastomeric primer is required. Activated with hardeners, these adhesives are highly exothermic and difficult to keep in large batches for much longer than 3 hr unless cooled.

Urea-formaldehydes, the common wood adhesives, are not as strong or as moisture resistant as the resorcinols, but are cheap, light-colored, and non-staining, and therefore particularly good for sandwich facings of light wood and thin veneer. Top service temperature is about 140 F, and a pressure cure of 150-200 psi for 6-12 hr is required for handling. Although 6-10 days at room temperature is needed for best properties, cure time can be accelerated by baking at 200 F.

Modified phenolics are new twists on the well-established phenolic wood adhesives. By combining phenolics with other resins—vinyls, neoprenes, and nylons, for example—chemists have evolved adhesives that will wet a greater variety of sandwich materials, provide greater flexibility than the phenolics, yet retain their strength. Some modified phenolics have improved water resistance too. Here are the main modified phenolics:

Vinyl-formal phenolics are hybrids—part thermoplastic, part thermosetting adhesives. The thermosetting characteristic dominates—with the vinyl thermoplastic plasticizer giving added toughness and impact strength. For metal honeycomb panels and wood-metal sandwiches, vinyl-modified phenolics are generally considered one of the best balanced adhesive types now available. Shear and peel strengths remain high over a fairly broad temperature range, −67 to 300 F. Resistance to creep is good, although these adhesives betray thermoplastic origins by softening somewhat as temperature exceeds 200 F. Fatigue resistance is typical of tough thermosetting resins, with failure occurring in the adherends rather than in the adhesive. Equivalent to nitrile-phenolics in shear strength, the vinyl-phenolics have slightly better self-filleting qualities, but lower peel strength. Where sandwich loads tend to peel the structure apart, a vinyl-phenolic would be chosen over an epoxy, for example, even though shear strengths are equivalent.

Supplied as liquid resin, or in cloth-supported film form, vinyl-phenolics are cured under pressure and heat. Volatiles are one problem with the liquid form, and must be driven off, before bonding, by force-drying. Properly cured, these adhesives have good resistance to

COMPARISON OF ADHESIVE TYPES . . .

	ADHESIVE TYPE	Normal Film Thickness, mils	Setting Method	CURING CONDITIONS			Reaction Byproducts	TYPICAL STRUCTURAL (ASTM	
				Pressure, psi	Temperature, °F	Open Time, min.		Shear, psi (D-1002-53T)	Tensile, psi (D-897-49)
Thermosetting	Epoxy	4–8	Heat cure [1]	Contact to 150	200 for 40 min.	— —	None	2000–3000 [2]	3000–6000
	Phenolic and Modified Phenolic	5–20	Heat cure [1]	15–250	240–450	3–120	Water	2000–5000	1000–4000
	Vinyl-Formal Phenolic	2–6	Heat cure	50–500	240–300	—	Volatile fumes	3000–5000	1000–4000
	Vinyl-Butyral Phenolic	5–7	Heat cure	10	300	—	Water	2000–5000	1000–4000
	Elastomer Modified Phenolic	9–11	Heat cure	25–150	300–375	—	Water	1500–5000	8000–15000
Thermosetting-Thermoplastic	Neoprene-Rubber base (including phenolic-modified neoprenes)	2–6	Air-dry	1–100	RT-200	2–60	Solvent or water vehicle	200–700	200–800
			Heat cure	15–250	250–400	3–120	Water	2500–5000	2500–5000
	Nitrile-Rubber base (including phenolic-modified nitriles)	2–10	Air dry	Contact to 100	RT-200	2–10	Solvent or water vehicle	200–2000	500–2000
			Heat cure	15–250	280–400	3–120	Water	2000–6000	4000–8000
Thermoplastic	GRS base	2–10	Air dry	Contact to 100	RT-200	2–30	Solvent or water vehicle	50–300	—
	Reclaimed-rubber base							50–200	200
	Polyvinyl Acetate	1	Air dry	Cure at room temperature; pressure not required but inproves strength.			Water	300–400	—

(1) With catalyst; no catalyst: 350 F for 60 min.; (2) 2500-5000 for modified epoxies;

weather, salt spray, humidity, oil, water and aromatic fuels.

Vinyl-butyral phenolic adhesives possess many properties of the vinyl-formal types. They have high shear strength at room temperature, but this drops as the thermoplastic temperature of the vinyl is approached. In both shear strength and toughness, they are somewhat inferior to the vinyl-formal adhesives. Most popular application is bonding metal or reinforced plastic facings to resin-impregnated paper honeycomb cores.

Elastomer-modified phenolics get around the major disadvantage of phenolic adhesives—inherent brittleness. By plasticizing with elastomers, flexibility is added, along with peel strength, and extended high temperature resistance. Solvent removal can be a problem when impervious sandwich materials are heat-cured, unless the film form is used. Forced drying prior to bonding removes this problem, however. Most common elastomer additions are neoprenes and nitriles, and the cured bonds are very resistant to fuels, humidity, and salt spray. Nitrile-phenolics are particularly outstanding here, having the best salt-spray resistance of the high-strength adhesives.

Neoprene-phenolics are particularly suited for metal sandwich panels because these materials will take the high curing temperatures—about 250-400 F after force-drying the applied adhesive to a tacky state at 180 F

FOR SANDWICH PANELS

STRENGTHS METHOD) Peel, lb/in. width (D-903-49)	Creep and Fatigue Resistance	Water and Humidity Resistance	Service Temp. Limits, °F	Flow Characteristics	Solvents	Method of Application
2–15	Excellent	Good	−65 to 500	Self-filleting; no volatiles so unperforated honeycomb can be used	None	Knife-coat Roll-coat Film
0.5–5	Excellent	Good, withstands 6 FPL[3] cycles	−40 to 200	Heavy film thickness required	Ketone Alcohol	Spray or brush
Good	Good	Excellent	−65 to 300	Medium to heavy thickness required for honeycomb cores	None	Spray or brush Roll-coat Film
8–10[5]	Excellent	Good withstands 6 FPL cycles	−65 to 300	Self-filleting heavy syrup, diluted with ketones for spraying	Alcohol-toluol blend	Spray Roll-coat Film
Poor	Excellent	Good, withstands 6 FPL cycles	−65 to 300	Not self-filleting, but adaptable to honeycomb and porous cores	None	Film
15–50	Excellent	Good, withstands 6 FPL cycles and 2000-hr water soak	−70 to 250	Not self-filleting, but adaptable to honeycomb cores; thin syrup, penetrates porous cores	Ketone Toluol Naphtha-ketone blends Water	Spray or brush Roll-coat Film
6–25	Excellent	Excellent, 6 FPL cycles	−70 to 300			
15–40	Good, second only to neoprenes	Good, second only to neoprene-base adhesives	−70 to 250		Ketone Water	
75–80[5]	Excellent, also good impact resistance					
6–28	Fair	Good, second only to nitriles; water dispersions are fair	−40 to 200	Thin syrup to mastic; for porous cores, use mastic or water type	Naphtha Water	Spray or brush
6–20	Poor	Better than GRS water types, poorer than GRS solvent types	−20 to 150			
—	Fair	Fair	RT to 250	Not self-filleting to honeycomb; brittle after curing at 275 F	Water	Brush Roll-coat Spray

(3) Forest Products Lab accelerated weather test cycles; (4) Two-part acid curing system available; (5) climbing-drum peel test (in. lb)

before bonding under pressure. Fatigue and impact strengths range from 3000-5000 psi. Resistance to creep and plastic flow is excellent, and joints can sustain high continuous loads for long periods. Wood-to-metal bonds often have a neoprene-phenolic primer where straight phenolic or resorcinol-phenolic adhesives are the primary bonding agent. In film form, neoprene-phenolics give high strength bonds between metal honeycomb cores and metal facings, with highest strengths obtained when a special wetting agent is applied. Normal temperature range is from −70 F to 300 F, although strength at the high end is about half that at room temperature.

Nylon-phenolics offer excellent adhesion to many sandwich materials, strong durable bonds, good damping properties, and resistance to chemicals. Chief use at present is in aircraft, though rubber-modified varieties are being evaluated for industrial use.

Acid-catalyzed phenolics have better water resistance and lighter color than straight phenolic adhesives, and are commonly applied to metal facings on plywood and other porous cores, if a primer is first applied. This can be either a vinyl-phenolic or an elastomer-phenolic adhesive. Curing is speeded by heating to 250 F.

THERMOSETTING-THERMOPLASTIC

Although this group of sandwich panel adhesives is often termed medium-strength and semirigid, high

strengths can be achieved by heat curing. Generally, though, these adhesives are noted for good peel strength plus moderate shear strength combined with low cost, and low-temperature cure–and are among the most widely used and competitively sold.

Neoprene rubber-base adhesives, reinforced with thermosetting or thermoplastic resins, are the most versatile of the low-cost sandwich cements. Most of them attain strength through solvent release; a few contain curing agents and fillers for special properties. Because the compounding is so flexible, noeprene adhesives can be cured four ways:

- **Conventional method** is to coat the surfaces, dry to proper tackiness, assemble the panel, and cure between platens under heat and pressure. Disadvantage is long time cycle, but this method gives strong bonds.
- **Fastest method,** aimed at high-speed sandwich construction, is to force-dry coated surfaces under infrared lamps until the adhesive reaches thermoplastic state. Assembling the sandwich and passing it through rubber-coated nip rolls completes the structure.
- **Cold method** is possible too. Here, both surfaces are coated and air-dried 5 to 60 minutes until an apparent "no-tack" condition is reached. Pressing the facings and core together now produces a bond that will support stress immediately, and is but slightly weaker than a heat-cured joint.
- **Dry film method** gives highest strength joints and is well suited to metal facings and cores. Best joints result from surfaces primed with liquid adhesive, dried in air, and pressed together with the dry film between. Assembly is then heat-cured to give semirigid bond that will yield slightly upon loading locally, so that stresses are redistributed as in ductile metals.

Adhesion to many different surfaces–from metals and reinforced plastics, to paper and foamed plastics–is an outstanding quality of neoprene adhesives. They also exhibit high shear and peel strengths, age well, and resist weather, ozone, oils, mild acids and alkalis. Because they are solvent drying, their effect on foamed plastic cores should first be checked. Some adhesives will sustain low loads at elevated temperatures soon after bonding, an important property for two reasons: Some panels undergo a paint bake cycle directly after bonding, while others are formed slightly during the heat-pressure cure and might spring apart after assembly pressure is removed.

Nitrile rubber-base adhesives can be either thermoplastic or thermosetting, depending on the modifying resin. **Thermoplastic** types age well, have fair water resistance and good peel strength. Chemical resistance is less than for the neoprenes, although resistance to oils, naptha solvents, and some aromatic solvents is good. In addition, solvents in nitrile cements will lift paint and craze plastics–limiting material choice.

Shear strength of thermoplastic nitriles goes to about 2000 psi, and top load temperature is about 160 F. Bonding is by air cure, or for the upper limits by heat cure. Air-cured properties can be brought close to the heat-cured by heat-aging the sandwich panel above 250 F after assembly.

Thermosetting nitriles are usually modified with phenolic resins for better adhesion and higher strength, with shear values running to 6000 psi and service temperatures to 250 F. Some, in film form, are useful to much higher temperatures. For example, at 300 F, shear ranges from 1500 to 1800 psi; at 400 F, shear strengths to 800 psi are attainable. In addition, impact strength, and creep and fatigue resistance are improved over thermoplastic nitrile adhesives.

Generally, heat-curing thermoplastic nitriles are limited to moderate-load-bearing sandwich panels, and thermosetting types are selected for resistance to heat and high shear stresses. Both types are available in liquid or dry film form. For max peel strength in a nitrile, film form is sandwiched between core and facing after priming each with a liquid solution of the film formulation–sprayed on and dried before bonding the panel.

THERMOPLASTIC ADHESIVES

In many sandwich panels low-strength cores like foamed plastics are selected, usually for such nonstructural purposes as thermal insulation or sound deadening. Here, the "weakest link" principle applies, and the low-strength, low-cost thermoplastics–particularly the synthetic rubber-based, one-part adhesives–are widely chosen. Application is by spray, brush, or roll-coat–followed by forced drying under infrared lamps or warm air blowers, and bonding of core to facing by nip rolls or simple stacking.

Reclaimed rubber is a low-cost base for sandwich adhesives with good peel strengths, fair shear strengths, and good high-humidity resistance–a combination useful in nonstructural sandwiches. Many are available, differing sharply in strength, heat resistance, and tack range. But like natural rubber, they all lose strength at about 160 F and become brittle near −20 F, depending upon the reinforcing resin. Viscosity varies from thin syrup to heavy mastic, and vehicle can be either water or solvent. Where facing or core is porous, a solvent solution with high solids content penetrates and grips best.

GRS rubber as an adhesive base offers two plus factors over natural or reclaimed rubber: superior aging qualities, and greater resistance to high temperature. Special compounding will push top service temperature to about 200 F. In creep, GRS adhesives out-perform reclaimed rubber adhesives, but are inferior to the neoprenes and nitriles. Water resistance is good in solvent solution, but only fair in water dispersion.

Polyvinyl acetate adhesives, of all the thermoplastic vinyl formulations, are the best suited for sandwich construction–especially the two-part, chemically-catalyzed types with operation temperatures to 180 F. Most of the common polyvinyl acetates are water dispersed and adhere well to wood, some metals, glass and many porous materials. Chief disadvantages are brittleness of bond, and water vapor released on cure, which lowers bond strength and water resistance unless the panel is vented.

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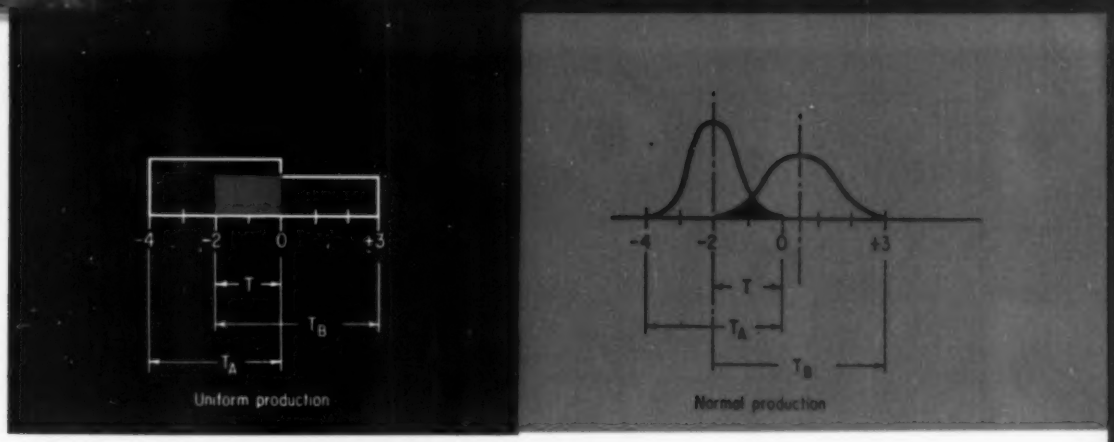


Number of misfit assemblies . . .
will depend, to some extent, upon whether production is "uniform" or "normal." Uniform is when acceptable parts are chosen from a large number of parts or parts are made on a one-at-a-time basis. Normal production implies mass production on automatic or semi-automatic machinery. In this example, range of tolerances on parts *A* and *B* (T_A and T_B) allows same overlap, *T*, but number of rejected sets (shaded area) is less when production is normal.

EQUATIONS PREDICT

Chance of Misfit in Assembly

Tight tolerances aren't always necessary—sometimes you can gamble on wider ones that save money and will often work satisfactorily. But before gambling, know the odds.

W. HANKA, *Dipl. Ing., Military Aircraft Factory, Cordoba, Argentina*

Suppose you don't specify close tolerances when dimensioning two or more mating parts. That involves some risk of misfit. But balance the risk against expected savings in over-all production expense. Wider tolerances cost less and do not need careful machining. And it can be shown that the chance of actual misfit is often very small. A gamble, yes. Whether to take the chance boils down to knowing beforehand just what the risk of misfit will be.

The methods given here for dimensioning parts realistically, rather than insisting on tight tolerances, were successfully used by the author when working with English industry during World War II. They are especially valuable when it is necessary to find the risk of misfit for more than two mating parts.

These methods predict the number of assemblies that will be rejected—whether because of too little or too much clearance. Probability of misfit here assumes that production is **uniform** (sometimes called "rectangular"). That is, a part with maximum or minimum dimensions and one with average dimensions have equal chances of appearing for assembly. By using a graph, probability for uniform production can be translated into probability for **normal** production (where most parts have mean dimension; a few have max or min dimension).

I—FITTING TWO PARTS

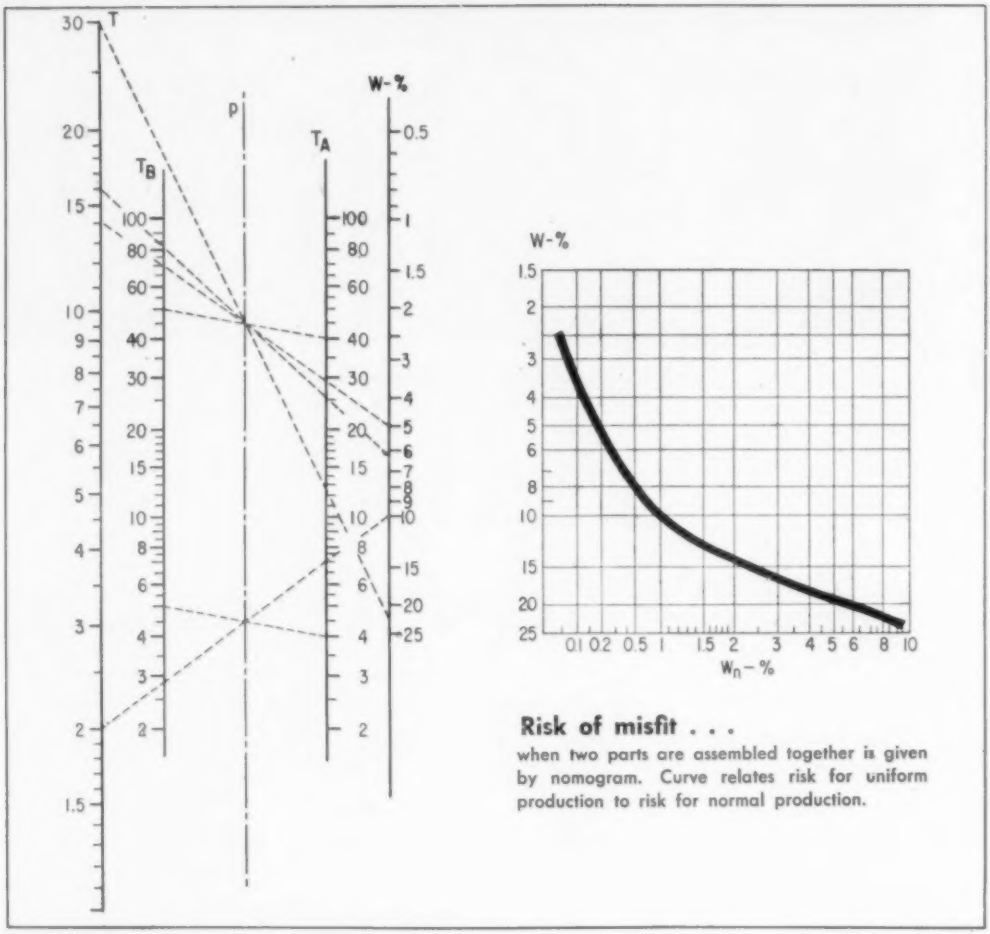
The probability of mismatch, *w*, when two parts (*A*, internal; and *B*, external) with certain tolerances are fitted together is given by the formula

$$w = \frac{T^2 - a_1^2 - a_2^2 + b_1^2}{2\,(T_A)\,(T_B)}$$

where T_A is range of tolerances on part *A* and T_B is range of tolerances on part *B*. *T* is "transgressed tolerance"—the tolerance that exceeds the limit for acceptable parts. And a_1, a_2, b_1 are defined as follows: $a_1 = T - T_A$, $a_2 = T - T_B$, $b_1 = T - (T_A + T_B)$. When a_1, a_2, b_1 are negative, they are dropped from the equation.

The equation is flexible in its application; it can give probability for either too much or too little clearance. For determining chance of too little clearance or of interference fit, *T* is max dimension of internal part minus min dimension of external part—the extent of interference. And *T* for clearance fit is *A* min minus *B* max—the max possible clearance.

EXAMPLE 1—A 10-in. shaft (tolerances: +0.0015; +0.0036) and 10-in. hole (+0.0033; −0.00) are toleranced for a transition fit (where some sets of parts



Risk of misfit . . .
when two parts are assembled together is given by nomogram. Curve relates risk for uniform production to risk for normal production.

give clearance fits, others give interference fits). If production is uniform, how often will these tolerances give interference fit?

All tolerances are multiplied by 10^{-4} for convenience in computation.

$T = 36 - 0 = 36$ $\quad a_1 = 36 - 21 = 15$
$T_A = 36 - 15 = 21$ $\quad a_2 = 36 - 33 = 3$
$T_B = 33 - 0 = 33$ $\quad b_1 = 36 - 21 - 33 = -18$

Then:

$$w = \frac{36^2 - 15^2 - 3^2}{(2)\,(21)\,(33)} = 0.766 \text{ or } 76.6\%$$

Normally one would subtract 76.6% from 100% to give 23.4%—the chance of clearance fit. To obtain it directly, compute as before, but now $T = 33 - 15 = 18$; and a_1, a_2 and b_1 are all negative.
Then:

$$w = \frac{18^2}{(2)\,(21)\,(33)} = 0.234 \text{ or } 23.4\%$$

When transgressed tolerance T is less than T_A or T_B, then a_1, a_2 and b_1 are all negative, and the equation reduces to

$$w = \frac{T^2}{2\,(T_A)\,(T_B)}$$

which is easily adapted to solution by nomogram. The nomogram (shown above) includes an attached curve showing comparison between probabilities for uniform and normal production. Notice that as w approaches 2.5%, w_n becomes negligible and as w approaches 50%, w_n approaches the value of w.

EXAMPLE 2—In assembly, a 5-in. shaft (+0.00; −0.004) has to go into a 5-in. hole (+0.003; −0.002). What is probability of interference fit?

Since T (0.002) is less than T_A (0.004) and T_B (0.005), nomogram can be used. A line is drawn between $T_A = 4$ and $T_B = 5$ on nomogram. Another line, between $T = 2$ and previous intersection with p axis, intersects w axis at 10%. The curve shows, however, that a 10% chance of misfit in uniform production is equivalent to $w_n = 1\%$ in normal production—a very small chance of misfit.

The nomogram is also valuable in setting tolerances on two parts where a given clearance is desired.

EXAMPLE 3—A slide fits within a guide and a clearance must be maintained between the two mating parts. Experiments showed that for a slide 8 in. wide, the clearance should be a maximum of 0.0090 and a minimum of 0.0030. Tolerances on the slide were set at +0.00 and −0.0040 and on the guide at +0.0030 and +0.0080—with nominal dimension being 8 in. With these tolerances, max clearance is 0.0120 and

min clearance is 0.0030. Max clearance exceeds max allowable clearance by 0.0030 (T). Probability of getting clearance of more than 0.0030 is found on nomogram when $T_A = 40$, $T_B = 50$ and $T = 30$. Probability is 8% in normal production.

Without tightening tolerance it is possible to get fewer parts with too loose a fit and still maintain very small risk of getting parts with too tight fit. Dimensions are displaced so that each part has same range of tolerances but clearances between parts are reduced. Displacing slide tolerances by 0.0016 in. (to +0.0016 and −0.0024) reduces probability of getting parts with clearance of more than 0.0090: from $w_n = 8\%$, to $w_n = 0.2\%$. And probability of getting parts with not enough clearance (less than 0.0030) increases to only 0.35%. With a simple change in dimension, clearances have been kept within acceptable limits for most assemblies without tightening tolerances.

II—FITTING 3 PARTS OR MORE

Equation for mating two parts is a simplified form of a more basic equation which holds for mating of any number of parts. It gives probabiilty of misfit when assuming, as before, that production is uniform. And again, values for normal production, w_n can be read from curve.

The assumption in deriving the generalized equation is that there are only a finite number of possible dimensions falling between max and min limits. For example, a part with ±0.003 tolerances is assumed to have only seven possible dimensions: −0.003, −0.002, −0.001 . . . etc. In assembling sets of parts, then, there will be only a finite number of sets and only a finite number of rejects because of too much or too little clearance. Dividing the rejects by total number of sets results in probability of rejects due to misfit.

Probability equation for any number of mating parts

$$w = \frac{T^s - a_1^s - a_2^s \cdots + b_1^s + b_2^s + \cdots - c_1^s - c_2^s \cdots}{s!\,(T_A)\,(T_B)\,(T_C)\cdots}$$

where, as before T is transgressed tolarence; T_A, T_B, T_C are range of tolerances for parts A, B, C respectively. Other values are:

s is number of mating parts

a values are transgressed tolerance less tolerance range for each part: ($a_1 = T - T_A$, $a_2 = T - T_B$ . . .)

b values are transgressed tolerance less combinations of two tolerances ranges ($b_1 = T - T_A - T_B$, $b_2 = T - T_A - T_C$ . . .)

c values are transgressed tolerance less combination of three tolerance ranges ($c_1 = T - T_A - T_B - T_C$ . . .)

d, e, . . . values subtract combinations of four, five . . . tolerance ranges from transgressed tolerances.

Note that a values are subtracted, b values are added, c values are subtracted, etc. If any of the values, a, b, c . . . are negative they are dismissed from the computation.

EXAMPLE 4—A set of parts: $A = 4$ in. (tolerance +0.003, −0.00); $B = 3$ in. (+0.003, −0.00); $C = 5$ in. (+0.003, −0.00) can have a max dimension of 12.009 in. If tolerances on each part are widened 0.001, what is probability of exceeding 12.009?

Here $T = 0.003$, $s = 3$, $T_A = T_B = T_C = 0.004$. The values a, b and c are all negative because individual tolerances on all parts are greater than T and equation reduces to:

$$w = \frac{T^s}{s!\,T_A T_B T_C} = \frac{(3)^3}{(2)(3)(4)(4)(4)} = \frac{9}{128} = 0.07 \text{ or } 7\%$$

And in normal production, chance of misfit w_n (from curve) is only 0.4% or 4 set out of 1000. It is therefore possible here to widen tolerances 0.001 in. on each part and reduce machining costs with very small chance of misfit at assembly.

In many situations, a, b, c . . . will not be negative but will enter calculations as shown in the following:

EXAMPLE 5—Four parts: $A = 3$ in. (tolerances: +0.002; −0.001); $B = 2$ in. (−0.001; −0.004); $C = 3.5$ in. (+0.003; −0.00); $D = 1.5$ in. (+0.001; −0.001) are assembled within external part, $E = 10$ in. (+0.003; −0.002). What is probability of interference fit?

Transgressed tolerance $T = A$ max + B max + C max + D max − E min = 0.007. Value for s is 5. Other values are:

$T_A = 2-(-1) = 3$	$a_1 = T - T_A = 4$	$b_1 = T - T_A - T_B = 1$
$T_B = 3$	$a_2 = 4$	$b_2 = 1$
$T_C = 3$	$a_3 = 4$	$b_3 = 2$
$T_D = 2$	$a_4 = 5$	$b_4 = 1$
$T_E = 5$	$a_5 = 2$	$b_5 = 2$
		$b_6 = 2$

Other b values are negative and all c values are negative.

$$w = \frac{7^5 - (3)4^5 - 5^5 + (2)2^5 + (3)1^5}{5!\,(3)(3)(3)(2)(5)} = 0.39 \text{ or } 39\%$$

Probability of clearance fit can be computed, same way, and give 61%. Here, however, T is max possible clearance or E max − A min − B min − C min − D min = 0.009.

Equations can also be used to show probability of keeping clearance within permissible design limits as shown in . . .

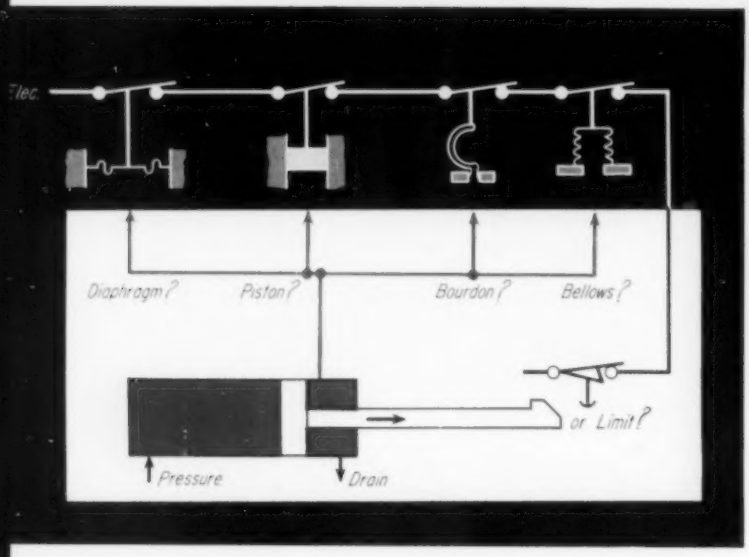
EXAMPLE 6—Good results were obtained with a roller bearing when clearance between roller and outer race was held between 4 and 25 units (1 unit = 0.00004 in.). Outer race is 1.6 in. (tolerances: +26 units; + 6), rollers are 0.2 in. (+1; −2) and inner race is 1.2 in. (+0; −9). With these tolerances, min clearance falls within acceptable limits (4 units) and max clearance is 39 units or 14 larger than acceptable maximum. If tolerances of outer race are displaced 8 units to +18 and −2, what is the probability of obtaining clearance less than 4 units? Transgressed tolerance is 8 units and other values are computed as before:

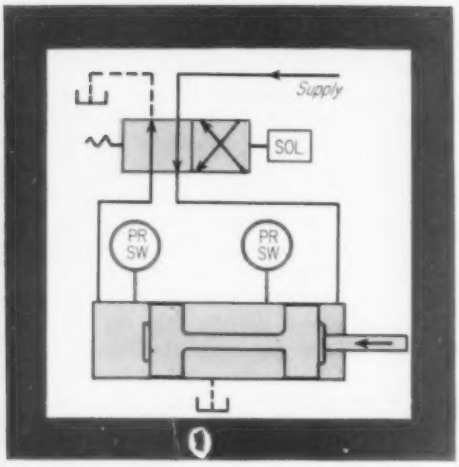
$$w = \frac{8^4 - (2)5^4 + 2^4}{4!\,(9)(3)(3)(20)} = 0.072 \text{ or } 7.2\%$$

And probability of misfit in normal production (from curve) is only 0.45%. Furthermore, probability of clearance exceeding 25 units is:

$$w = \frac{6^4 - (2)3^4}{4!\,(9)(3)(3)(20)} = 0.029 \text{ or } 2.9\%$$

The curve shows this is less than 0.1% in normal production. It is evident from this example that risk of misfit can be reduced by simply changing basic dimensions of a part without introducing change of tolerance or methods of production. ■





End-of-travel indication . . .
is given when piston passes port and actuates pressure switch (sketch at left). It is positive and senses pressure level as well as position. Valve shown above is solenoid-operated, but may also be manual.

when to use PRESSURE SWITCHES to indicate completed movement

Usually a pressure switch is picked to check pressure . . . but here is an example of using it like a limit switch, to check location. Article also compares advantages and limitations for both switch types.

E. E. OPEL
Electrical Engineer, National Automatic Tool Co., Inc.

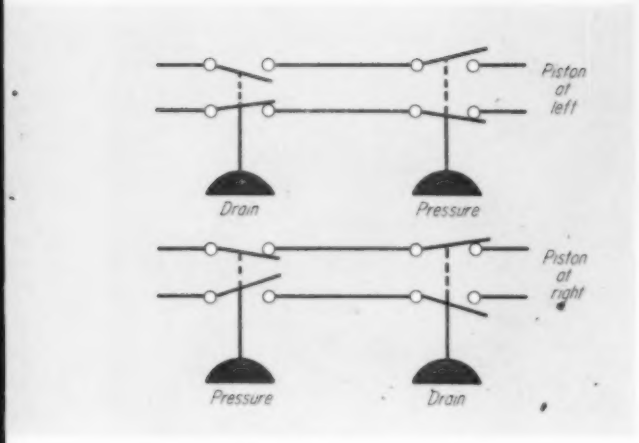
The pressure switch is officially declared a "black sheep" in JIC (Joint Industry Conference) Electrical Standards E-14.4.2-T which states: "Pressure switches shall not be used alone to determine sequence of operations."

What led to this restriction? The fact is that careless application rather than faulty operation caused some unfavorable field experience. Proper recognition of the purpose and ability of the pressure switch will insure good life and performance.

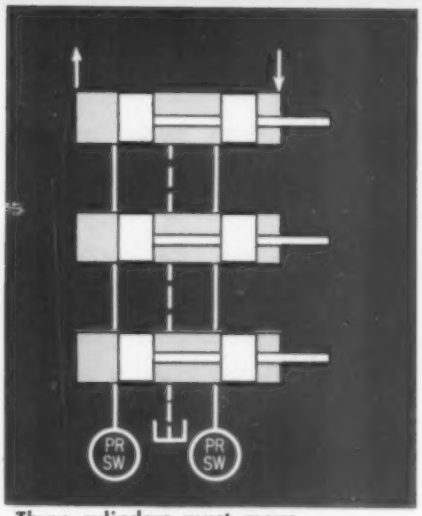
For example, pressure switches connected to cylinder supply lines can indicate that proper pressures have been reached in clamping and holding operations. They can help limit hydraulic or pneumatic forces pressing bushings into holes, and provide warning signals when lube-system failure occurs. They can be remotely located. However, sequencing operations that depend on pressure levels to trigger the steps must be handled with caution—sticking parts can upset the pressure schedule.

Limit switches can tell that a cylinder has completed its stroke, a clamp has moved into position, and an overspeed device in a rotating shaft has triggered out. They cannot detect whether the cylinder contains the right pressure or if the clamp holds firmly. Because they are unable to operate remotely they must be mechanically close.

Pressure and limit switches working together can verify that the correct position has been achieved at



Electric circuit . . .
for position indicator above signals completion only if both pressure switches function. One switch can indicate correct position; the other, proper pressure.



Three cylinders must move . . .
before signal reaches pressure switch. Electrical circuit is same as for single cylinder.

the scheduled pressure, but more electrical circuits will be needed.

PRESSURE SHOWS LOCATION TOO

In some cylinder operations, pressure switches can dependably indicate position as well as pressure, when special ports are provided. Function is similar to a computer element, because it signals either YES or NO. YES is the signal signifying that the plunger has traveled to the end and pressure is at or above that required. NO is a signal that the plunger is at the opposite end of its stroke. If only position is important, the pressure can be adjusted low. When three plungers are involved, all must complete travel before a pressure signal reaches the switch.

OVERPRESSURE AND ABUSE

Peaks and valleys of pressure and other disturbances can falsely actuate pressure switches. For example, jammed cylinders, pulsating pumps, excessive back-pressures in drain lines, trapped oil (which can be prevented by a drain line) and fast-operating valves may cause surges, "flutter," or other abnormal pressure conditions. These faults may trigger high-pressure switches and drop out low-pressure ones. Note that pulses, which may be too rapid to register on gages with surge protectors, can break switch diaphragms, destroy sequences, and blow gaskets.

High ambient temperatures may deteriorate electrical insulation, warp plastic switch housings, damage bellows, bake out composition diaphragms. Two devices may look identical, yet one may operate at 170 F, the other at 350 F. High vibration can shake a bellows to pieces. Dirt in the signal fluid can jam piston-operated pressure switches because of continuous leakage flow through them. Maladjustment and other human abuses also cause field failures.

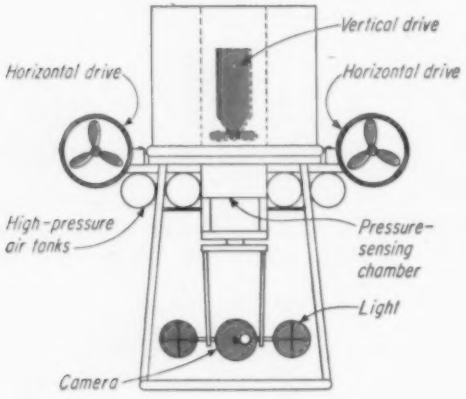
Proper application and maintenance lead to good switch operation. Evaluate all of the "ifs" for each circuit and be sure the switch is up to each requirement. Keep drains and vents large. Limit response speed to minimum needed, and maybe add accumulators and surge protectors to cushion flow. Provide time delays in electric circuitry to permit some fluttering without false triggering. Choose sturdy pressure switch types such as piston-actuated if pressure surges and vibration are unavoidable. Use bellows, bourdon, or diaphragm types for leaktight service. Above all, don't consider pressure switches as afterthoughts—get expert advice early.

EDITOR'S NOTE: Basic steps to obtain trouble-free circuit and component performance are given in "Maintenance Advice for Fluid Circuits," Mar 17 '58, p 71. Remote setting is possible with bellows actuation described in "Pressure Switch Can be Remotely Controlled," Dec 2 '57, p 40. An abstract, "Pneumatic-electric Relays," Mid-Oct '55, p J20, discusses not only the pneumatic-electric relay (pressure switch), but also the electric-pneumatic relay, which is a pressure switch in reverse.

Underwater Eye has Remote Controls

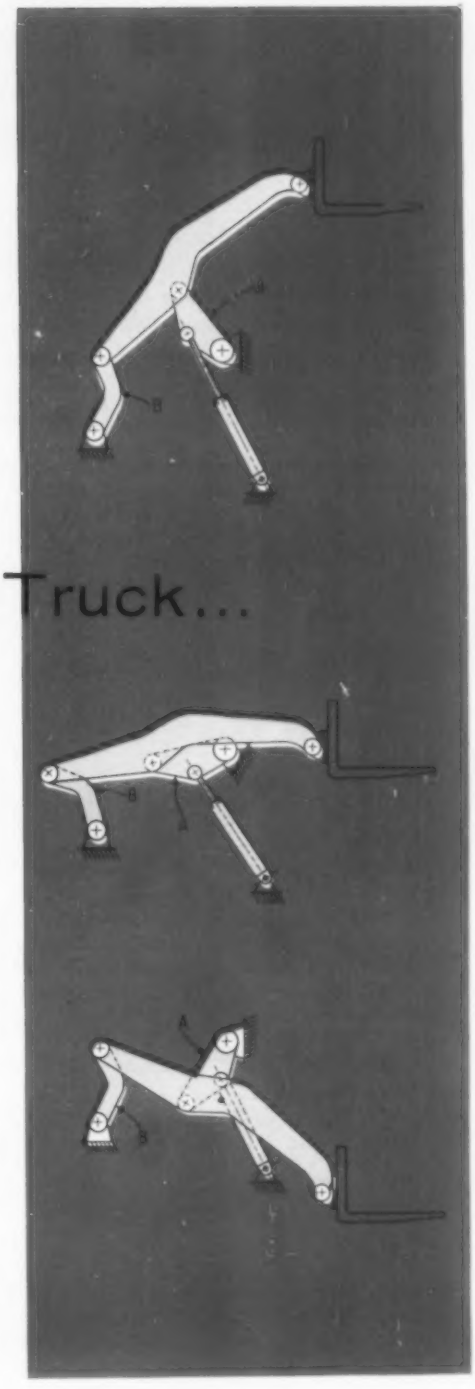
Salvage operations require the self-propelled carrier for this submarine television camera to maneuver somewhat like a helicopter. It's powered and guided through circuits carried in the same cable that brings closed-circuit TV signals to a control panel on the mother ship.

Hydrobot was developed by the General Engineering Laboratories of American Machine & Foundry Co. for the US Navy's Bureau of Ships. Designers were asked to provide a stable but maneuverable platform for the camera—one that could be guided from shipboard while finding and examining submerged objects. Carrier takes the camera to depths of 300 ft and maneuvers at speeds up to 1½ knots.



Variable-frequency power . . . drives the three propulsion motors that determine speed and direction. Direction is controlled by speed differential between the two horizontal drives. Vertical drive is in a well in toroidal buoyancy chamber. All are induction motors, develop 10 hp and have stators encapsulated in epoxy resin. No shaft seals are used and salt water lubricates the graphite sleeve bearings. Each motor has a 2-stage, 6:1-reduction gearbox which is also water lubricated. Gears are 17-4 stainless steel. Design philosophy called for simplicity in all underwater components at the expense of some extra complexity in the shipboard equipment.

Tubular frame . . . carries a buoyancy chamber, vertical and horizontal propulsion drives, airtanks and the TV camera and lights. Chamber makes carrier slightly buoyant and is pressurized to ambient water pressure. It houses electrical distribution systems, controls for depth gage and directional gyro, and pneumatic controls for cylinders that position camera and lights. No seals are critical; a skirt under the buoyancy chamber acts as a diving bell that keeps water away from cable entrance seals and senses pressure changes. A flowmeter measures relative water speed. Three operators at the shipboard console control depth and speed of the carrier, attitude of the camera and TV picture quality.



No Mast on this Lift Truck...

. . . Yet the load moves straight up instead of swinging through an arc. It's done with compensating links that shift the pivots as load arm is raised.

"Elbolift" truck weighs less; stability, maneuverability and visibility are improved. The lift was designed to meet a particular need of the canning industry—handling coils of rolled tinplate stock shipped on pallets. Continental Can Co. wanted a truck that would have sufficient head and elbow room inside boxcars. It presented the problem to Automatic Transportation Co., Chicago, and B. I. Ulinski, director of design and development, devised this lifting mechanism that met requirements. The truck is also used for loading the can-making machines—its fork blades fold to form a ram that fits the coil's eye.

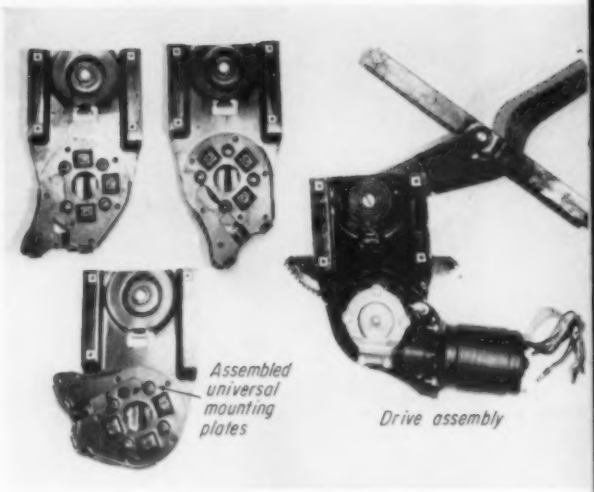
Coils are strapped . . .
to 52-in.-sq pallets that are loaded in boxcars. Truck had to be designed to enter the 8 x 8-ft boxcar door, pick up pallets as near as 1 ft, 7 in. to the doors and maneuver inside the car's 9-ft, 2-in. width. Coils weigh 15,000 lb each and are stacked three-high when unloaded. Stacking required lifting forks to tilt from 10° back to 5° forward and have an 8-in. side-shifting motion, for stack alignment. Maneuverability was obtained with rear-wheel steering.

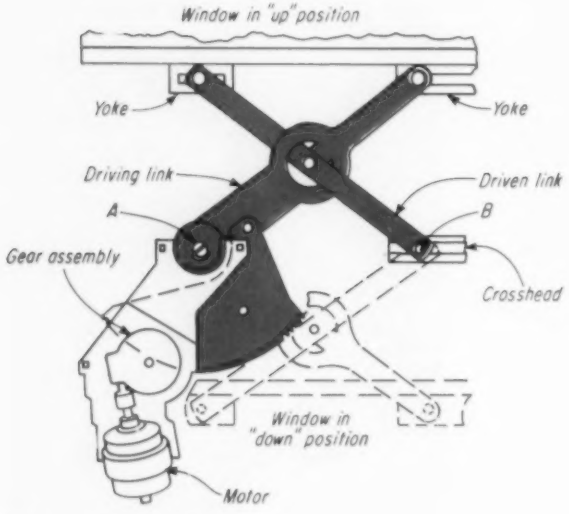
Straight-line lifting action is result of adding links A and B to the lifting mechanism. The load arm is raised by link A which arcs rearward as the hydraulic cylinder pushes it upward. Relative lengths of links A and B and the load arm let this action counteract the forward arcing motion of the swinging load arm. Load actually moves to rear as it is lifted.

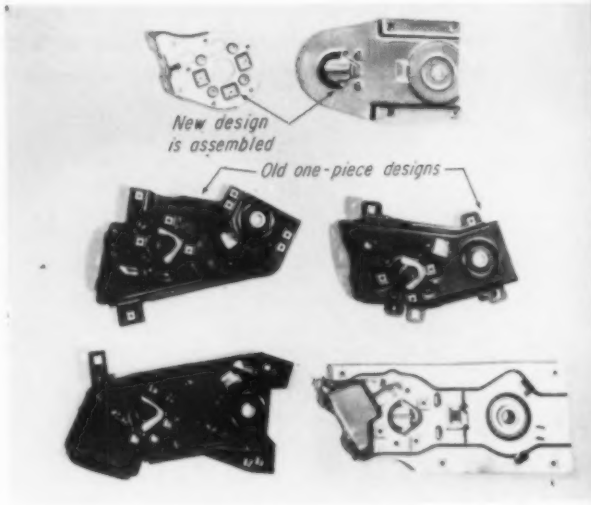
Welded Stampings Form Mounting Plates

Only three stamped parts are needed now to assemble mounting plates for electric window positioners in many makes of cars. They are a gear-support plate; right- and left-hand motor brackets.

As many as five different-shaped mounting plates may be required for a single car design: left and right front door, left and right rear door or rear quarter windows, and tailgate windows for station wagons. This shows why the Huppower Div. of Hupp Corp. has developed a universal mounting plate that fits most domestic and many foreign cars.

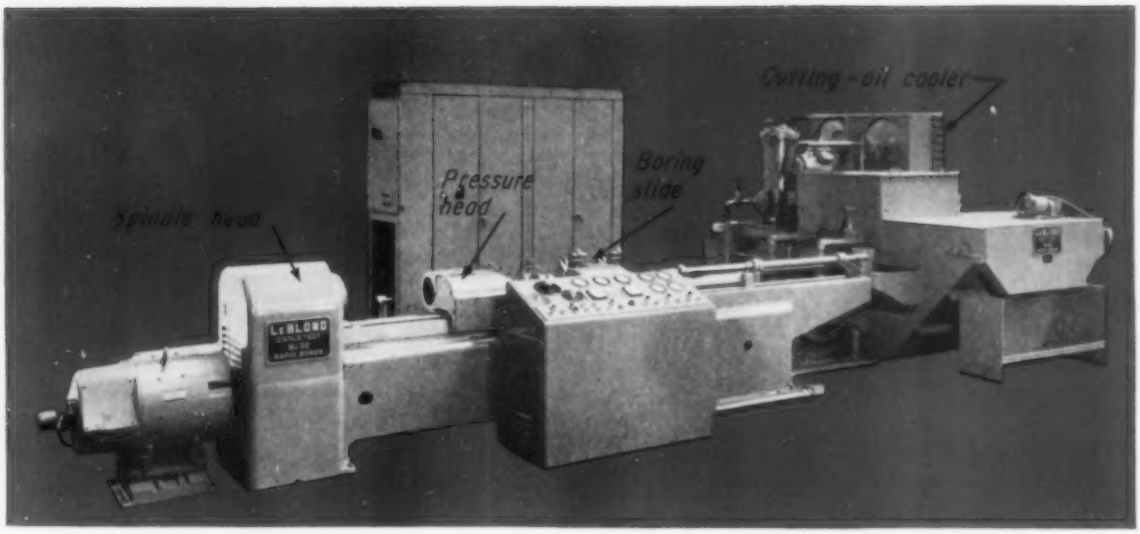






Scissors action . . . of motor-driven linkage applies equal actuating force to both ends of window. Motor drives output gear segment through a worm gear speed reduction and causes the drive link to pivot about point A. Other end of this link carries a pin that slides in a slotted yoke on the base of the window. The driven link is pivoted at the center of the driving link and carries sliding pins on each end; one slides in a second yoke on the window base, the other in a cross head at the same level as point A. When the gear segment rotates the driving link about A, the driven link rotates an equal amount about sliding pivot B. All parts are assembled on the mounting plate installed in the door panel.

Before universal plate . . . was designed, a variety of plates were made to fit various body and door styles (lower photo) and each required dies costing about $10,000 that had to be amortized over a relatively small number of cars. Principal variation in plates was relative position of motor and drive mechanism. Dies for new plates cost about $25,000 but are amortized, in two or three years, over production of many car designs. Parts are projection-welded in simple jigs (see the photo at top).

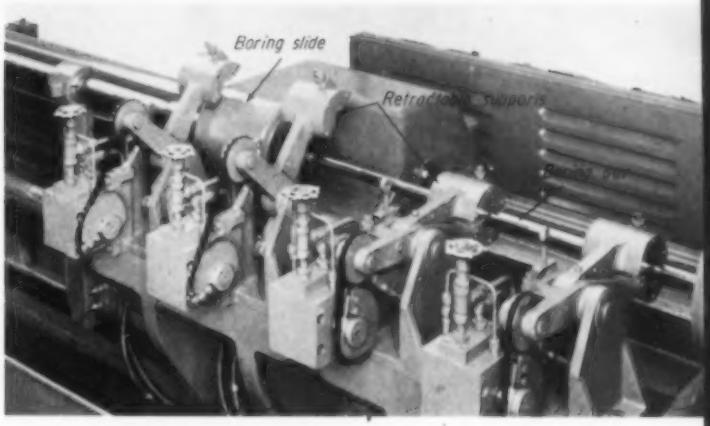


Coolant is Key to Rapid Boring

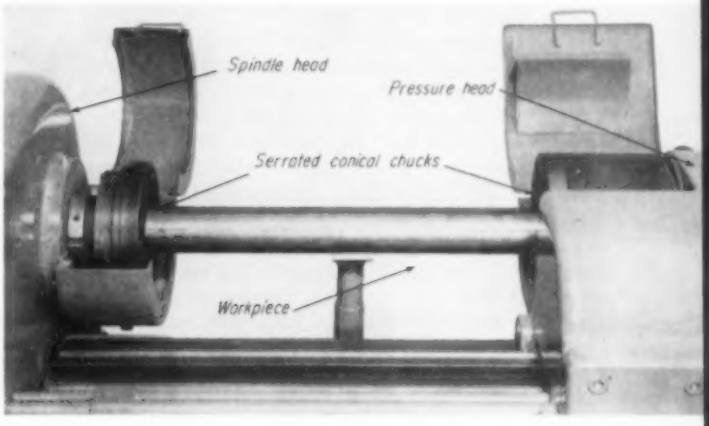
High-pressure cutting oil here forms a hydrostatic bearing that centers the boring bar, also flushes chips into the hollow tool as fast as they are formed. Result: long holes bored 3 to 8 times faster than with conventional lathes.

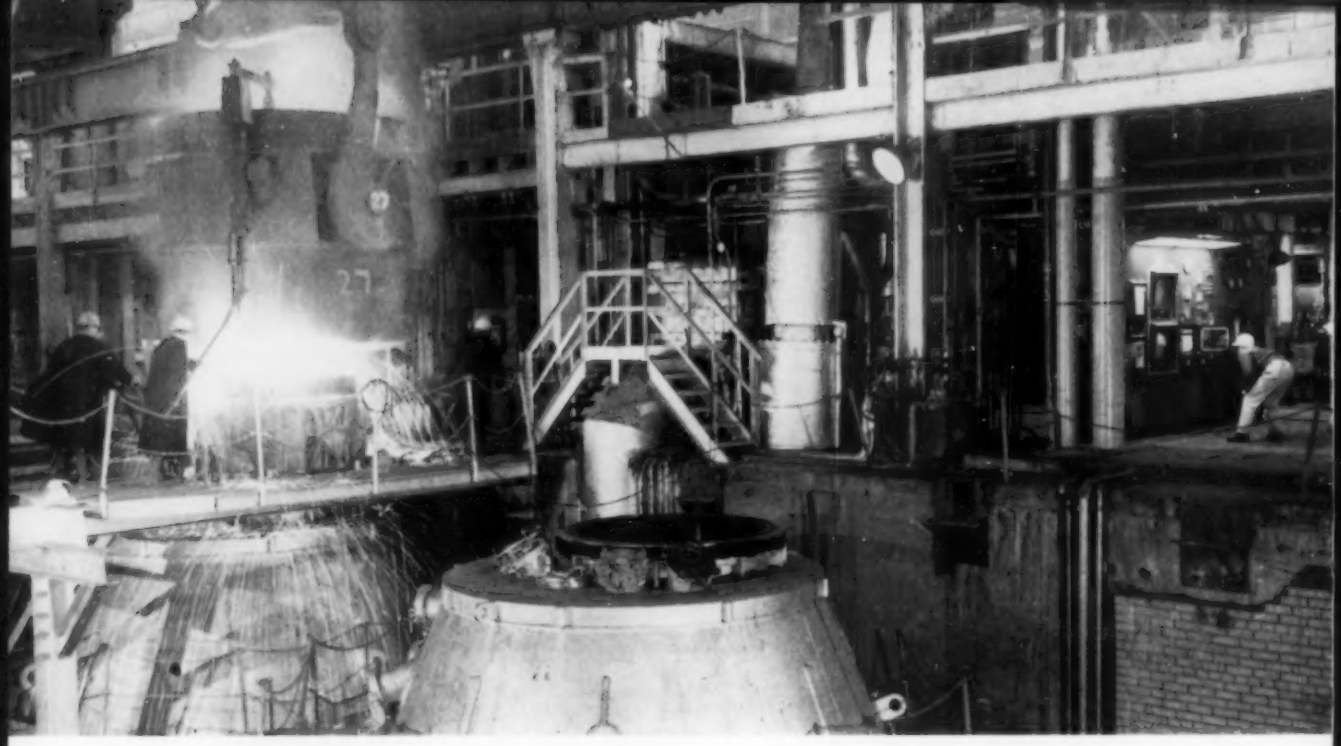
A high-capacity cooling system keeps oil temperature around 95 F in this machine called the LeBlond-Carlstedt Rapid Borer, designed to get maximum speed and cutting accuracy from modern tooling. It can solid-bore, trepan or counterbore holes from 5/16 to 4¼ in. dia. The manufacturer is R. K. LeBlond Co., Cincinnati.

Workpiece is held . . .
in serrated conical chucks in pressure head and drive spindle—spring-loaded O-ring seals prevent leakage of cutting oil. The oil is forced into the bored hole at 800 to 900 psi, at rates up to 145 gpm—flow is 49 gpm for a 1 7/8-in.-dia hole. The 4-ton-capacity cooling system keeps the oil temperature differential within 6 F. Machine will bore a ¾-in.-dia hole in brass at 24 in. per min and in steel at 4 in. per min. Thrust on tool can be as much as 4000 lb at speeds of 3000 rpm. A 30-hp motor drives spindle.



Vibration is controlled . . .
by supporting the boring bar throughout its length. Special supports near the pressure head open as the boring slide advances to where interference would occur. These supports, plus pressure-head spindle and the hydrostatic bearing formed by cutting oil, prevent vibrations from affecting accuracy and finish of the bored hole. A belt drive in the spindle head gives added stability.





VACUUM STEEL

J. H. STOLL, *Chief Metallurgist*
Bethlehem Plant, Bethlehem Steel Co.

Where forging applications require bigger ingots, vacuum pouring (also see our cover) insures against flakes, reduces nonmetallics, gives better ductility. Already proven for high-strength forgings in large sizes, method shows promise in other fields too.

Another size barrier has been broken. The advantages of vacuum casting have paid off in sound forgings larger than previously possible. They are made from steel ingots poured in vacuum. These forging ingots are going into shafts of turbo-generator units and promise wider possibilities for large forgings in other critical, highly stressed applications. Vacuum pouring means added ingot costs, but these are offset by the reliable forgings that result.

The size breakthrough was stimulated by the need for larger turbines and generators with better efficiencies –in turn leading to a need for larger rotors. But sound rotor shafts of such size weren't easy. Hydrogen could normally diffuse sufficiently out of small steel sections, but was trapped in large ingots. It was responsible for the flakes and microcracks that contributed to failures which damaged expensive equipment and even cost lives. Therefore, manufacturers hesitated to build units having rotors much larger than 50 in. dia. That limit no longer exists now that vacuum pouring gives ingots up to 120 in. dia.

A rival method–vacuum melting–gives even purer ingots. But it is not practical when very large ingots are needed–nor is there any need in many applications for the extreme high purity possible with vacuum melting. It was confirmed at the Bethlehem plant that pouring in vacuum will adequately remove gases and other impurities to a harmless level. The molten stream of metal is poured through a vacuum chamber that allows de-gassing to occur while the melt is filling an ingot mold. By using conventional melting equipment, the method eliminates one of the main roadblocks to large-scale vacuum treatment: After the ingot is poured, the vacuum has done its work and is no longer needed. The ingot is then allowed to solidify normally–in the uncovered chamber.

The method requires better refractories and additional personnel–more man-hours, extra equipment and more processing steps that can go wrong while making a pour. But for large parts, the added expense pays off in the long run. It helps insure against rejection of very large forgings in the final stages of machining where rejection means not only replacing the part but also losing up to six months' time.

Development Costs Were Cut

The promise of a sounder product justified building a 250-ton vacuum pouring unit. But to cut development costs and time, a 7-ton unit was built concurrently. Experimenting with this pilot unit:

Molten steel stars in this TV screen play where vacuum pouring is watched by metallurgist.

Giant shafts for turbo-generators are now possible, thanks to vacuum pouring. Photo at left shows molten steel dumping into one of twin 250-ton molds where it will form reliable ingots for rotors.

GROWS UP

• Reduced development costs—obviously a 7-ton ingot destroyed for testing is less expensive than a 250-ton ingot.

• Saved time—because it was completed months ahead of the large unit, extra time was available for pilot runs and when the large unit was completed, it could be put to work immediately.

• Gained know-how—techniques worked out for the small unit established procedures for the first heats in the 250-ton unit.

TV Helps Too

The pouring operation is watched by two television cameras. One camera is focussed on the stream of molten metal, the other looks directly into the mold. In production, the molten stream is observed through the TV screens to see if it is entering the mold properly.

Higher Ductility

For a given strength, vacuum-cast metals are more ductile than air-cast metal even when it is aged to remove hydrogen. For nickel-vanadium-molybdenum alloy steel, hardened to the same ultimate and yield strengths, the ductility is considerably higher. For the same ductility, this advantage allows the steel to be hardened to a higher tensile strength. Other alloy steels of the chrome-vanadium-molybdenum grades promise similar improvements and are being investigated.

Vacuum pouring is no cure-all. For each particular steel and size, the given improvements in ductility and cleanliness will have to be justified economically. One limitation should be remembered: Vacuum-pouring does not necessarily eliminate segregation. When large ingots solidify, the segregation which comes from progressive freezing is not materially affected.

Among other results promised by vacuum pouring is casting of ingots for rolled products. For both large and small ingots, the method gives higher ductility in directions transverse to the direction of work. This may give forgings with more uniform directional properties.

Other indirect advantages expected are: shortened delivery time for wrought steels; lowered mill costs because long heat-conditioning treatments now necessary for avoiding flakes may not be needed.

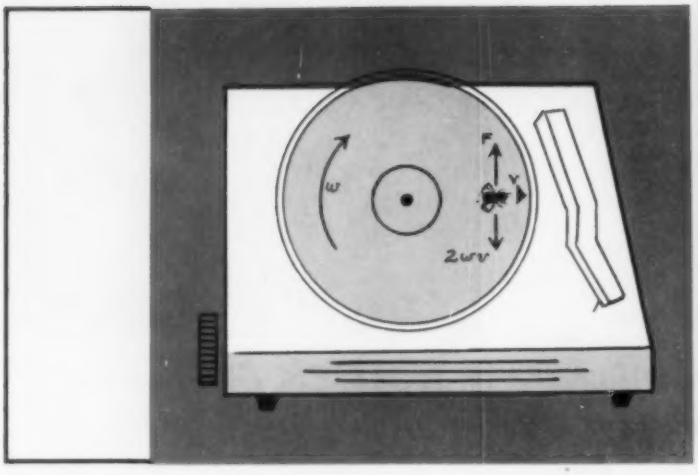
Although vacuum pouring promises potention savings, it is an added step and therefore adds to costs. So applications for this premium steel have been limited to large forgings that are critically stressed.

EDITOR'S NOTE: Other applications for vacuum, a new industrial tool, are covered in:

"Vacuum Coatings Go Industrial," Dec. 23 '57, p 67. Once limited to decorative uses, these metal films are finding many industrial applications such as in the corrosion-resistance and miniaturization fields.

"Vacuum-melted Alloys for Forged Parts," Feb '57, p 147. Gives advantages and limitations of consumable electrode and induction processes; effect on cleanliness, segregation and high-temperature properties.

SPINNING HOUSEFLY



SOARING MISSILE

A fly walks on a turntable—he's mystified by a force urging him to his left . . . A missile soaring over the Northern Hemisphere feels the same force—but to the right:

CORIOLIS ACCELERATION—

Here's an analysis that reduces the mystery to simple equations and also shows how the force affects specific mechanical components such as planetary gears.

NICHOLAS CHIRONIS, *Associate Editor*

Any object moving over the surface of a rotating "frame of reference"—whether the reference is the earth's surface or a machine part—experiences a force at right angles to its direction of motion.

This force was first publicized in 1835 by a French engineer, Gasper Coriolis. He showed that the ordinary Newtonian laws of motion can serve in a rotating frame of reference only if the equations allow for a "fictitious" force. It acts to the right of the direction of relative motion for a counterclockwise rotating reference and to the left for a clockwise rotation. The force is now described as Coriolis "force," "acceleration," or "effect," depending on application. Besides affecting everything that moves on or over the earth—winds, water, trains, airplanes, missiles—it is important in the dynamic analysis of mechanical components such as pumps, fans, cams, linkages and planetary gears.

As an illustration, assume that A at the center of a rotating platform (diagrams on opposite page) throws a ball at *B*, also on the platform. At that instant *C*, who is not on the platform, is in line with *A* and *B*. During the time it would take for the ball to reach *B*, the platform turns through an angle θ and the ball, of course, will miss *B*. To *A* and *B*, or for that matter to any observer on the platform (the rotating frame of reference), the ball seems to curve to the right of the direction of motion: the ball behaves as if influenced by a force field at right angles to its path. However, to someone on a stationary (inertial) frame of reference the ball will travel in a normal fashion—straight toward *C*.

The same effects hold true no matter what direction the ball is thrown, and no matter from what position. The ball will always seem to curve to the right to someone on the platform (and to the left if the platform is rotating clockwise). Of course if it is thrown from a point other than the center, the actual velocity will be the vector sum of the initial velocity and the tangential velocity imparted by the platform. Thus if *D* aimed at *E*, the ball will travel toward *F*, and the apparent Coriolis drift will be the distance from *E* to *F*.

The curve motion can be considered caused by an acceleration or force in accordance with Newton's laws. An accelerometer on an airplane flying a Great Circle route over the surface of the earth will indicate the presence of such a force—to the right in the Northern Hemisphere, to the left in the Southern Hemisphere—if the airplane is kept to its course.

This phenomena will also be experienced by an object traveling on the surface of the turning platform. Suppose a fly is walking radially outward on a turn-

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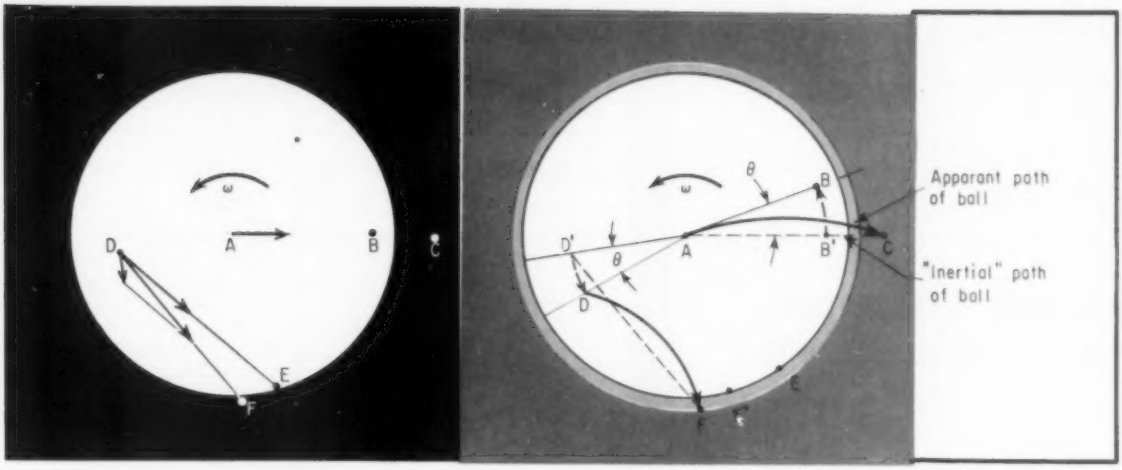


Coriolis drift . . . illustrated by rotating platform. Left: ball thrown form A to B will miss B but strike C. As viewed by B on a "rotating frame" of reference (right), ball seems to curve under influence of an acceleration force; as viewed by C on an "inertial" or "fixed" frame of reference, ball travels normally. Ball will also seem to curve to right from any other point, such as D.

a force to be reckoned with

table. If the fly's velocity is v and the turntable is rotating clockwise with an angular velocity ω, then as the fly moves outwardly its tangential velocity increases at a constant rate. A change in velocity means acceleration, and the fly will experience an acceleration to the left of the motion (and a countering force to the right) which will be proportional to ω and v. In addition, the fly is changing in direction because of the rotation. This directional change is also proportional to ω and v. Coriolis acceleration A will then be

$$A = 2\,\omega\,v$$

The force produced by this acceleration:

$$F = 2\,m\,\omega\,v$$

where m is the mass of the fly.

Also acting on the fly is a centrifugal force equal to

$$F_C = m\,r\,\omega^2$$

A Coriolis force will exist even if the fly is moving at right angles to a radial line—for example, along the circumference. In such a situation, the absolute tangential velocity of the fly will be the sum of its velocity with respect to the platform plus the tangential velocity imparted to it by the rotating platform. The "apparent" centrifugal force will now be greater, and can be considered as centrifugal force plus Coriolis force.

This example shows that a frame of reference rotating with constant angular velocity ω may be treated as a Newtonian (stationary) frame if to each particle there are applied the correct Coriolis and centrifugal force components.

The equation for Coriolis force is easily modified to suit the conditions on our rotating earth by adding the sine of the geographical latitude L. This compensates for the angle that the earth's surface makes with the spin axis—the analogy between a rotating platform and the earth's surface only holding entirely true at the poles. Hence, the variation in Coriolis acceleration with the latitude is

$$A = 2\,\omega\,v \sin L$$

The force is zero at the equator ($L = 0°$) and a maximum, $2\,\omega v$, at the poles ($L = 90°$). Knowing that the angular velocity of the earth is $\omega = 7.292 \times 10^{-5}$ rad/sec, a "Coriolis parameter," $C = 2\,\omega \sin L$, can be determined (table, next page) for various latitudes.

Some interesting data can now be computed. In the middle latitudes of the Northern Hemisphere, where $C = 1 \times 10^{-4}$, a shell fired with a 3000-ft/sec velocity at a target 20 miles away will miss its target by nearly 200 ft (neglecting factors such as wind resistance). The computations are:

$$A = Cv = \frac{v}{10000} = \frac{3000}{10000} = 0.3\ \text{ft/sec}^2$$

(Continued on next page)

CORIOLIS ACCELERATION— a force to be reckoned with

CORIOLIS Parameter

Latitude, degrees	Parameter, $sec^{-1} \times 10^{-4}$	Latitude, degrees	Parameter $sec^{-1} \times 10^{-4}$
0	0	50	1.117
10	0.253	60	1.263
20	0.499	70	1.370
30	0.729	80	1.436
40	0.938	90	1.458

Time necessary for the shell to reach its target is

$$t = \frac{\text{distance}}{\text{velocity}} = \frac{20 \times 5280}{3000} = 35.2 \text{ sec}$$

Keeping in mind that the acceleration is at right angles to the shell, the acceleration will cause a displacement x of

$$x = \frac{1}{2} At^2 = \frac{0.3 \times 35.2^2}{2} = 186 \text{ ft}$$

Gunnery officers consult suitable tables to compensate for this drift. Germany's giant World War I cannon, Big Bertha, underwent a Coriolis drift of almost a full mile when shelling Paris from a distance of 70 miles. The problem is even more pronounced with modern-day missiles.

Returning to that ball being thrown from one person to another, if the moving platform made one revolution every 12 sec, the ball was thrown at 20 ft/sec and the players were 10 ft apart, the drift would be

$$A = \frac{2 \times 2\pi}{12} \times 20 = 21 \text{ ft/sec}^2$$

$$t = \frac{10}{20} = 0.5 \text{ sec}$$

$$x = \frac{1}{2} (21) (0.5)^2 = 2.6 \text{ ft}$$

The Coriolis acceleration is involved in many other geophysical phenomena. It causes moving water to veer off to the right in the Northern Hemisphere. Thus rivers such as the Mississippi erode the right bank more than the left. It is reported that more than 80% of the asymmetrical valleys on Long Island have a steeper west slope. This effect has also occurred in Siberia according to two Russian scientists, Slavsov and von Baer —the effect being stronger in the higher latitudes.

The motion of winds is highly affected by Coriolis acceleration. If the earth didn't rotate, air currents would move in a fairly simple pattern—hot air would rise at the equator and cold air from the poles would move to the equator. There would be little circulatory movement—no opportunity for hurricanes, cyclones and typhoons to develop. In actuality, warm air traveling away from the equator (in either hemisphere) is deflected eastward, and air traveling toward the equator is deflected westward. Thus in the Northern Hemisphere, from about a latitude of 30° to 60°, the Coriolis acceleration gives rise to "prevailing westerlies" which sweep in an easterly direction.

Near the poles, where the effect is strongest, lost polar explorers reported a strong tendency to circle toward the right at the North Pole, toward the left at the South Pole. It is even said that penguins walk in leftward arcs in the Antarctic.

Coriolis acceleration may play a remarkable role in the migration of birds, according to Dr. H. L. Yeagley of Pennsylvania State College. He theorizes that many birds may have a special sensory organ which can detect slight differences in acceleration. By estimating ground speed during flight the birds may sense the geographical latitude. For them to pinpoint a location, however, he suggests that another sensory organ exists which senses differences in the minute magnetic field forces generated by the bird's motion through the earth's magnetic field. This provides a form of grid because the magnetic poles of the earth are displaced some 20° from the spin axis, making it theoretically possible for them to navigate.

Although this theory may seem rather improbable at first glance, Dr. Yeagley obtained remarkable results with homing pigeons. He trained them to "home in" at State College, Penna. A counterpart with similar grid values exists for this location in central Nebraska. The pigeons were shipped to Nebraska and released about 75 miles from their new homing destination. Many flew toward this point; in fact, statistical correlation was significant, giving credence to the theory.

REPRINT of this article can be obtained for your reference file by checking No. E25 on one of the Reader Service cards inside back cover. For other reprints available see "Current Reprints" listing in this issue on page 131.

CORIOLIS application to planetary gears

There are many types of machine components in which one part is moving on a body which is rotating relative to the ground or frame of the machine. In these cases, the Coriolis acceleration must be added vectorially to the other accelerations normally connected with the motions.

A good example occurs with planetary gears where unbalance in the system may cause vibration and fatigue failures. The system in this diagram has been analyzed by J. O. Predale, Associate Professor in Mechanical Engineering at the Newark College of Engineering. Computations are for one position only.

Given

$$\omega_2 = +50 \text{ rad/sec } (CW)$$
$$\omega_4 = -22 \text{ rad/sec } (CCW)$$

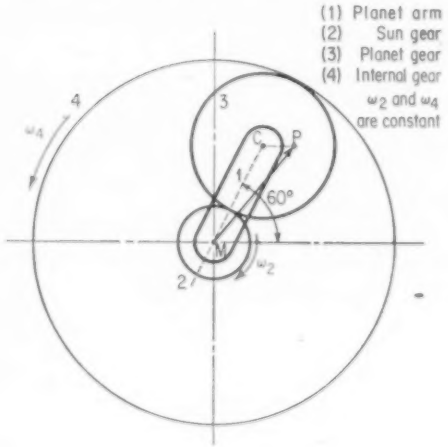
Pitch radii of gears in inches:

$$R_2 = 2\ R_3 = 4\ R_4 = 10$$

Point P is the unbalanced center of mass of gear 3;

$$CP = 1 \text{ in.}$$

Problem is to find the absolute acceleration of point P.



The angular velocity of the planet arm can be determined from the equation

$$\frac{\omega_{4/1}}{\omega_{2/1}} = \frac{\omega_4 - \omega_1}{\omega_2 - \omega_1} = \frac{R_2}{R_4}$$

from which $\omega_1 = -10$ rad/sec CCW
Similarly,

$$\frac{\omega_{3/1}}{\omega_{2/1}} = \frac{\omega_3 - \omega_1}{\omega_2 - \omega_1} = -\frac{R_2}{R_3}$$

$$\omega_3 = -40 \text{ rad/sec}$$
$$\omega_{3/1} = \omega_3 - \omega_1 = -30 \text{ rad/sec}$$

The absolute velocity of any point P on the planet gear is, in vectorial form:

$$\bar{V}_P = \bar{V}_{P/1} + \bar{\omega}_1 \times \bar{MP} \qquad (1)$$

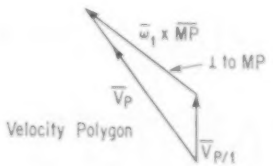
where

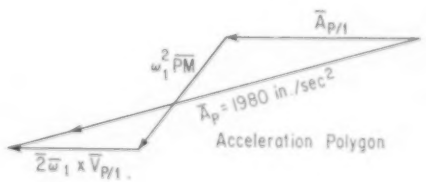
$\bar{V}_P$ = absolute velocity of P to fixed frame of reference
$\bar{V}_{P/1}$ = velocity of P relative to link 1.
$\bar{MP}$ = position vector measured in the moving coordinate system with a magnitude equal to length of MP and a direction from M to P.

Equation (1) is solved graphically by constructing the velocity polygon with these magnitudes:

$$V_{P/1} = \omega_{3/1}(CP) = 30\ (1) = 30 \text{ in./sec}$$
$$\omega_1(MP) = 10(6.56 \text{ in.}) = 65.6 \text{ in./sec}$$

Vector $\bar{V}_{P/1}$ is layed off on the velocity diagram perpendicular to CP, and $\bar{\omega}_1 \times \bar{MP}$ perpendicular to MP.





Differentiating Eq. (1) gives the acceleration equation which will hold true for any similar type of linkage.

$$\bar{A}_P = \bar{A}_{P/1} + \omega_1^2\,\bar{PM} + 2\bar{\omega}_1 \times \bar{V}_{P/1} \qquad (2)$$

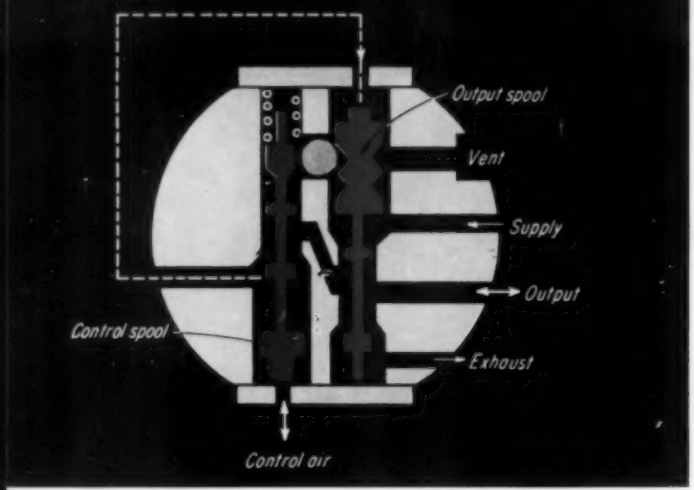
where $\bar{A}_P$ = absolute acceleration of P

$\bar{A}_{P/1}$ = acceleration of P relative to link 1
$2\bar{\omega}_1 \times \bar{V}_{P/1}$ = Coriolis acceleration of P

Vector $\omega_1^2\bar{PM}$ is directed from P toward M, and $\bar{A}_{P/1}$ from P toward C. The graphical solution of Eq (2) is given in the acceleration polygon using these magnitudes.

$$A_{P/1} = \omega^2_{3/1}(CP) = 900 \text{ in./sec}^2$$
$$\omega_1^2\,(PM) = 656 \text{ in./sec}^2$$
$$2\omega_1\,V_{P/1} = 2(10)\,(30) = 600 \text{ in./sec}^2$$

As to be expected, the Coriolis acceleration is perpendicular to the instantaneous direction of P relative to link 1, with a direction to the left. Omission of this factor in an acceleration analysis would have been a significant error.



1 Compact momentary . . . two-position valve is air-actuated. In this Class II mechanism a single pulse source (air here) triggers both extreme positions. Control-air pressure raises left spool, unlocking ball. Output spool rises because supply pressure works on unequal area. Output port and center section of control spool are now pressurized from supply. Removal of control pressure drops control spool, locking ball against still-raised output spool, and pressurizing top of locked output spool. In similar manner, next control pulse drops output spool; removal of pulse locks it.

PNEUMATICS:

valve with a memory

HANDLES LOGIC CIRCUITS

As in electrical circuitry, the logic function called MEMORY can also be used in valving air. The valve holds the position last called for, is therefore useful in automatic sequence applications.

RUSSELL J. CAMERON, *Pres., Ross Operating Valve Co.*

Even the ordinary household light switch has an obedient memory. It remembers your latest wish . . . flick it on or off and it stays. Yet only in the past few years has there been a simple, fast-acting pneumatic valve (sometimes called a "momentary") that can do the same with air circuits.

MEMORY, of course, is not the only logic function. The other logic functions (AND, OR, NOT) are already common for air. For example, ordinary control valves in series (all must be opened before flow can start) demonstrate AND. In parallel (any one can transmit the flow signal) they represent OR. NOT is simple; it can be a valve that closes (on signal) to halt flow.

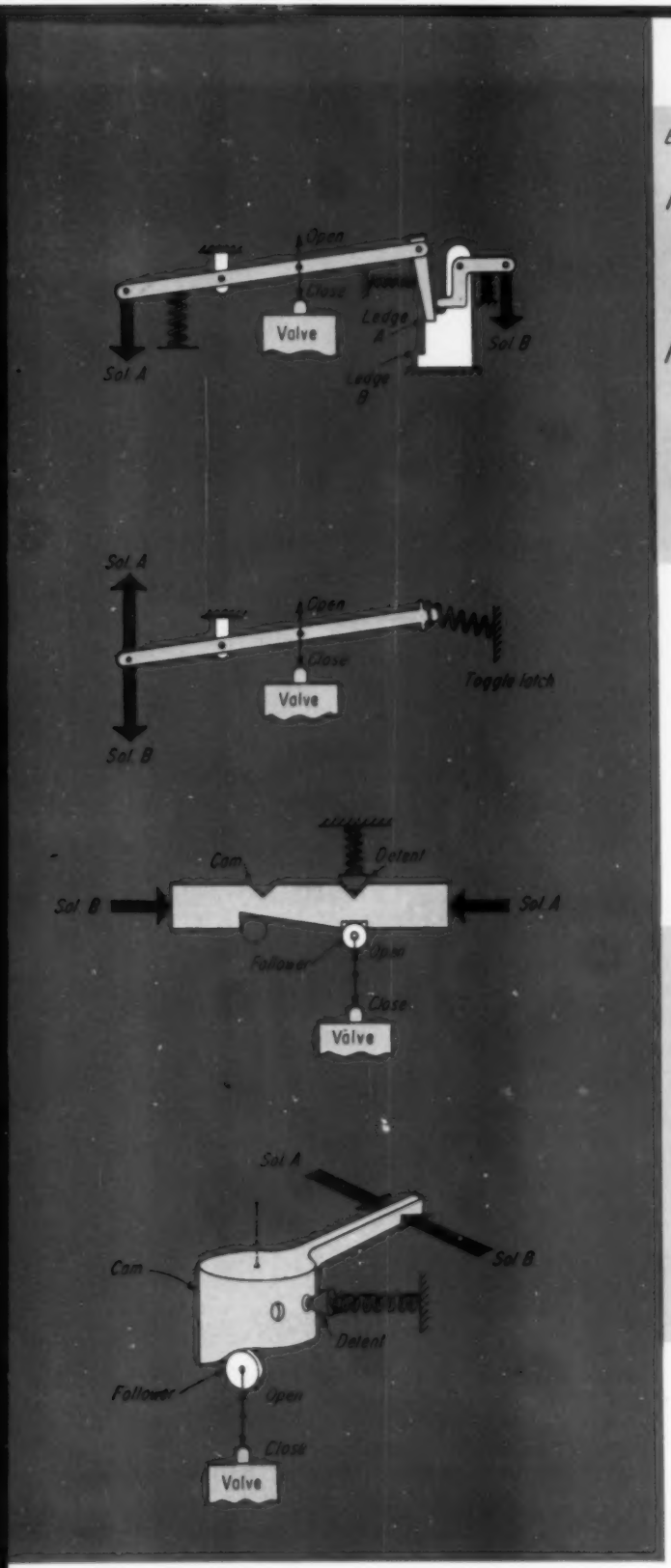
MOMENTARY-TYPE MECHANISMS

MEMORY is handled easily by a momentary-type valve. A single, brief pulse (pneumatic, electric, or mechanical, depending on design) will move it to end-of-stroke in one direction. Here the valve is held (by latches, detents, magnets, or other positive means) until a second pulse reverses it. It is bi-stable because no intermediate position is possible. Removal of the pulse, after the valve strokes, has no effect. It may therefore be said that two signals—a pulse, and removal of a pulse—result in one action.

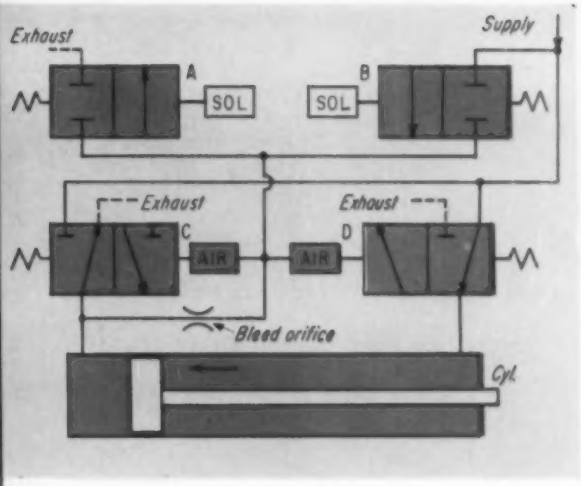
Momentaries come in two classes. Class I requires separate signal sources for each direction. For example, one solenoid drives valve in first direction, but a separate solenoid is needed for reversal. Class II, conversely, uses only one signal source: first pulse gives full travel in one direction; second pulse reverses.

A two-position solenoid valve, Fig. 4, is not considered a momentary because continuous energization of the

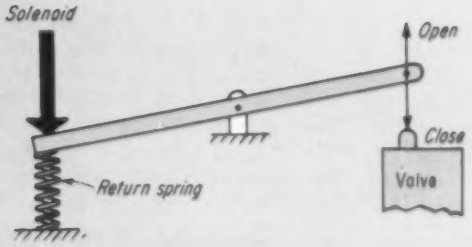
(Text continued on page 78)



2 Two-solenoid momentary . . .
valves, called Class I, move mechanism to one extreme position when solenoid *A* is pulsed, to the other when solenoid *B* is pulsed. Each position locks at end-of-travel; (A) and (B) have levers and latches; (C) and (D) have cams and detents.

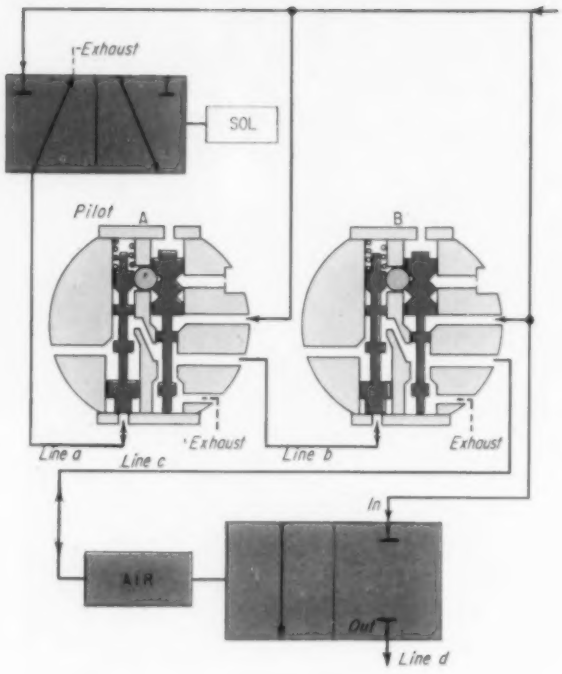


3 Standard 2-way and 3-way . . .
valves can be arranged, but not simply, for Class-I momentary action. Brief pulse of solenoid *B* sends air to pilots of valves *C* and *D*, which reverse, moving cylinder to right. Bled air to pilots holds *C* and *D*. To return piston to left, solenoid *A* is pulsed, dumping pilots to reverse *C* and *D*.



4 Non-momentary valves . . .
such as this simple two-position solenoid valve require continuous energization to hold the unbalanced position.

Pulse Number	Line Condition			
	a	b	c	d
1	P	P	P	open
	E			
2	P	E		
	E			
3	P	P	E	closed
	E			
4	P	E		
	E			
P is pressure; E is exhaust				



5 Counting with air . . .

is possible with stacked momentary valve units. Each unit output is pressurized for 1 pulse out of 2 (Fig. 1). Shown is two-unit stack; output is pressurized for first 2 out of 4 pulses (see table). For 3 units, output would be pressurized for first 4 pulses out of 8. Adding one unit always doubles number of pulses required to pressurize (or exhaust), and final signal will operate a valve.

solenoid is required to hold off-normal position. A separate latching relay is needed to make it function as a momentary valve.

Most momentary devices now available are Class I and operated by solenoids, Fig. 2. All can actuate balanced valves (such as pilot-operated valves) that require negligible holding forces at the end positions, but choice of detent is more critical if it must hold against an unbalanced spring-loaded valve. Disadvantages of these common types have been their complexity, large size, relatively short life (compared with ordinary solenoid valves), double actuation (Class I), non-matched speeds of response (quicker in one direction than the other), and often their cost. Sometimes elaborate systems are devised to use standard valves for momentary action, as in Fig. 3.

The "packaged," air-actuated, Class II momentary valve in Fig. 1 is designed to overcome most of the previous objections. Its compactness makes it particularly adaptable to logic circuitry.

Many electric, hydraulic and pneumatic circuits that involve logic functions are discussed in previous articles (see Editor's Note). Fig. 5 shows how a counting circuit can be made by simple stack-up of standard air valves. This counter could be used, for example, to schedule parts coming from an automatic assembly line: Four distinct signals (two pulses, two removals) complete one cycle and actuate a control valve which then might operate a sorter.

THE BI-STABLE SOLENOID

Mechanical latching for momentary valves has proven best so far, but a solenoid that holds magnetically at each end of travel with signal removed (bi-stable) may have possibilities. Study to date indicates dc is practical, but ac is not yet as dependable. Here is how the solenoid works:

The armature is semi-permanently magnetized as it pulls home, and therefore holds after solenoid is de-energized. Reversal of potential (or alteration of ac wave form) drives armature to opposite end of travel, and remagnetizes it to hold there. Experence has been poor with ac because of difficulty in timing cut-off of potential to coincide with peak of right polarity.

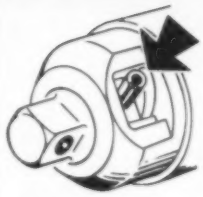
EDITOR'S NOTE: Tips for automatically controlling air, electric and hydraulic circuits appear in numerous previous articles:

"Switching-logic Functions," Aug '57, p 196, explains the AND, OR, NOT, and MEMORY concepts. "Hydraulic Control-valve Circuits," July '57, p 197, describes several control circuits using pilot, sequence, and other typical valves. "Compressed Air for Push or Pull," Oct 14 '57, p 72, shows how air valves and cylinders can be used for sequence operations. "Relays for Step-by-step Circuits," Nov 11 '57, p 101, summarizes role of stepping switches in automatic control; and "Simplifying Relay Control Circuits," Nov '56, p 162, outlines a graphical algebra method for representing switching circuits.

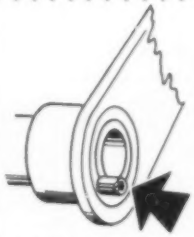
Several detailed abstracts help round out the air-relay story: "Design of Pneumatic Relay Circuits," Mid-Oct '56, p J8, uses electricity-air analogy to describe several simple circuits; and "Fundamentals of Pneumatic Control," Mid-Oct '56, p J18, pictures 13 circuits for sequencing purposes.

Conversion between electrical and pneumatic units is discussed in two additional abstracts: "Nomograms Relating Hydraulic, Pneumatic and Electrical Energy," Mid-Oct '56, p J22; and "Pneumatic-electric Relays," Mid-Oct '55, p J20.

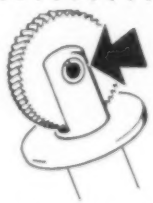
Rollpin® replaces 12 different fasteners



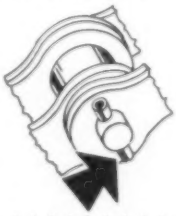
REPLACING A GROOVED PIN . . . in this application, Rollpin serves as a step pin in a ratchet wrench adaptor. With its light weight and high shear strength, Rollpin functions perfectly . . . cuts assembly costs.



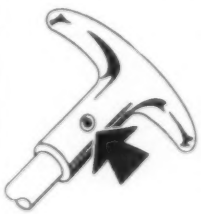
REPLACING A KEY . . . Rollpin demonstrates its ability to do away with precision tolerances, in this heating system damper arm. Faster, cheaper and more satisfactory than previous assemblies.



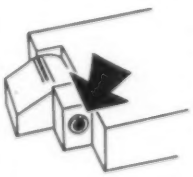
REPLACING A RIVET SHAFT . . . Rollpin serves as an axle for the sparkwheel of a cigarette lighter. No riveting or threading necessary . . . faster assembly. Note flush, clean fit.



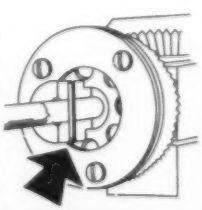
REPLACING A COTTER PIN . . . Rollpin assembly time is shorter, service life ten times longer. Vibration-proof flush fit. Easily removable.



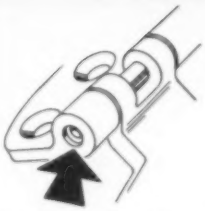
REPLACING A SET SCREW . . . to fasten automobile brake handle a short length Rollpin is self-retained in the hand grip but can easily be driven into over-drilled hole in shaft for simple handle removal.



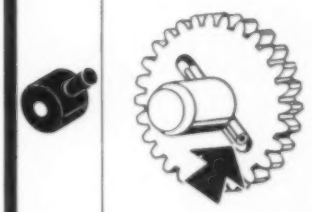
REPLACING A CLEVIS PIN . . . here Rollpin holds firmly in clevis, permits free action of moving member. Rollpin application shown is the plate of a home workshop tool.



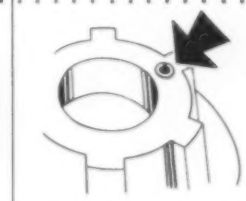
REPLACING TAPER PINS . . . in the assembly of precision differentials eliminated cost of taper pin reamers and the entire reaming operation. Rollpin costs less than a taper pin and installation is cheaper. They remove easily.



REPLACING A HEADED PIN . . . in this hinge pin application, Rollpin is simply and inexpensively driven in place, greatly reducing assembly costs. Constant spring tension holds Rollpin firmly in place . . . eliminates loosening of hinge due to wear.

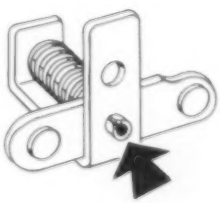


REPLACING A HUB ON A GEAR . . . Rollpin, self-retained in shaft, is simply snapped into molded slot to position sintered gear. This application, by an office equipment manufacturer, effects major savings in assembly. Rollpin's high shear strength is particularly valuable here.



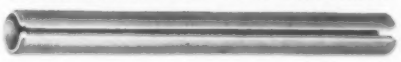
REPLACING A DOWEL PIN . . . Rollpin is used here to prevent rotation of a thrust bearing. No reaming, no special locking. Easily removed. Lowest possible dowel pin cost.

REPLACING A BOLT AND NUT . . . Rollpins act as fasteners and pivots for the linkages in this electric welder. Rollpins may be used with a free fit in outer or inner members depending upon product design requirements.



REPLACING A RIVET . . . Rollpin serves as guide shaft for spring-loaded electrical interlock contacts. This electrical equipment manufacturer reports that rivet failure previously occurred at the clinched end under normal operating impact and vibration.

WHERE CAN YOU USE THIS SIMPLE FASTENER?



Rollpin is the slotted tubular steel pin with chamfered ends that is cutting production and maintenance costs in every class of industry.

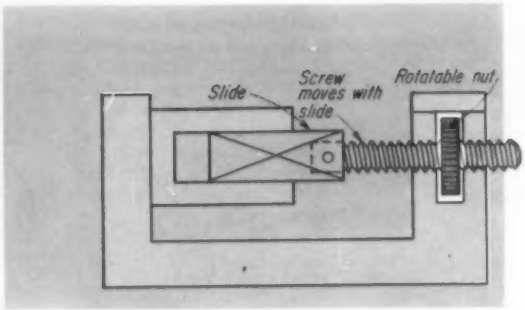
Drives easily into standard holes, compressing as driven. Spring action locks it in place—regardless of impact loading, stress reversals or severe vibration. Rollpin is readily removable and can be re-used in the same hole. Made in carbon steel, stainless steel and beryllium copper. Write for samples and information, ELASTIC STOP NUT CORPORATION OF AMERICA, 2330 Vauxhall Road, Dept. R47-52, Union, New Jersey.

ROLLPIN TRADEMARK

ELASTIC STOP NUT CORPORATION OF AMERICA
2330 VAUXHALL ROAD, UNION, NEW JERSEY

10 WAYS TO EMPLOY SCREW

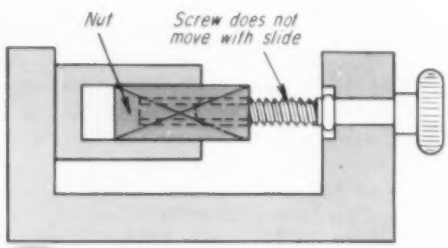
Three basic components of screw mechanisms are: actuating member (knob, wheel, handle), threaded device (screw-nut set) and sliding device (plunger-guide set).



1

Nut can rotate . . .

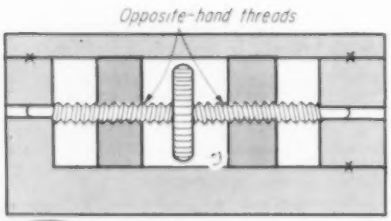
but will not move longitudinally. Typical applications: screw jacks, heavy vertically-moved doors; floodgates, opera-glass focusing, vernier gages, Stillson wrenches.



2

Screw can rotate . . .

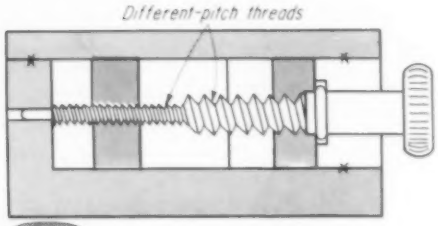
but only the nut moves longitudinally. Typical applications: lathe tailstock feed, vises, lathe apron.



3

Opposing movement . . .

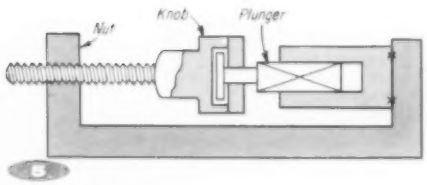
of lateral slides; adjusting members or other screw-actuated parts can be achieved with opposite-hand threads.



4

Differential movement . . .

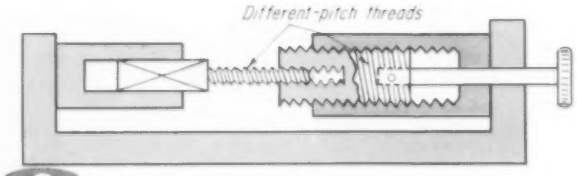
is given by threads of different pitch. When screw is rotated the nuts move in same direction but at different speeds.



5

Screw and plunger . . .

are attached to knob. Nut and guide are stationary. Used on: screw presses, lathe steady-rest jaws for adjustment, shaper slide regulation.



6

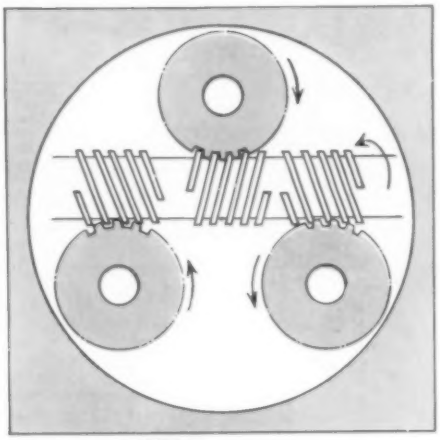
Concentric threading . . .

also gives differential movement. Such movements are useful wherever rotary mechanical action is required. Typical example is a gas-bottle valve, where slow opening is combined with easy control.

ELASTIC STOP NUT CORPORATION OF AMERICA
2330 VAUXHALL ROAD, UNION, NEW JERSEY
TRADEMARK

MECHANISMS

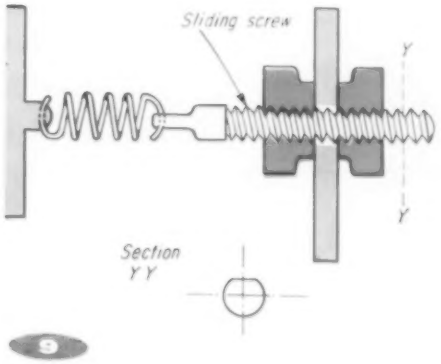
FEDERICO STRASSER, *Mankewitz and Strasser, Ltd., Santiago, Chile*



7

One screw actuates three gears . . .

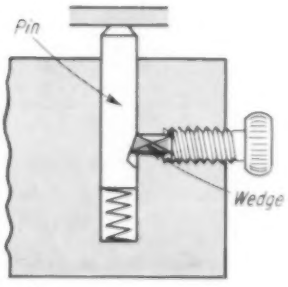
simultaneously. Axes of gears are at right angles to that of screw. This type of mechanism can sometimes replace more expensive gear setups where speed reduction and multi-output from single input is required.



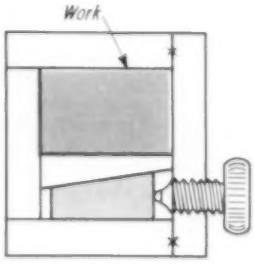
9

Locking nuts . . .

are often placed on opposite sides of a panel, to prevent axial screw movement and simultaneously lock against vibrations. Drill-press depth stops, and adjustable stops for shearing and cutoff dies are some examples.



(A)

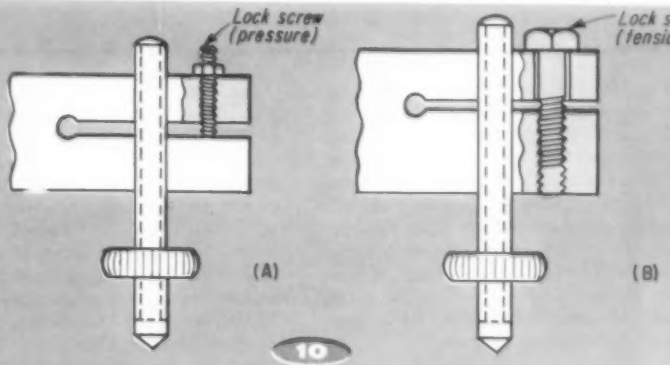


(B)

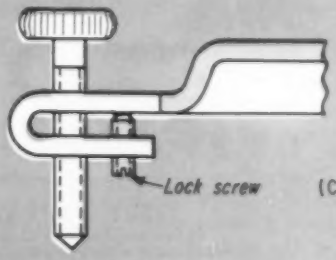
8

Screw-actuated wedges . . .

lock locating pin (A) and hold work in fixture (B). These are just two of many tool and diemaking applications for these screw actions.



10



Adjustment screws . . .

are effectively locked by either a pressure screw (A) or tension screw (B). If the adjusting screw is threaded into a formed sheet-metal component (C) a setscrew can be used to lock the adjustment.

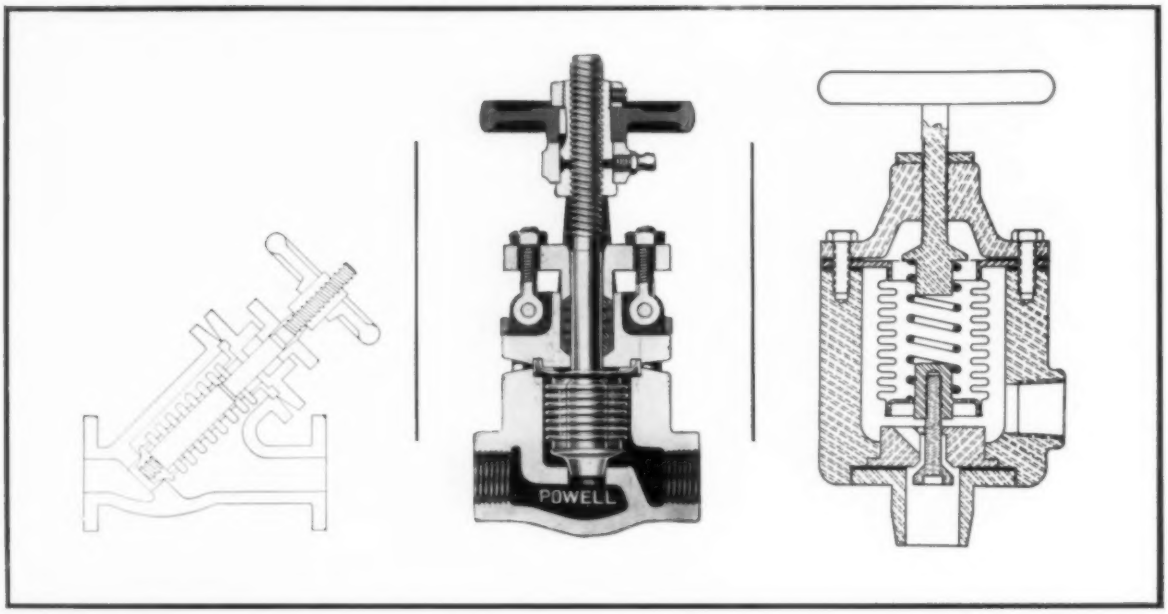
NEWS FROM FLEXONICS

BELLOWS APPLICATION ENGINEERING

One of a series of reports on more effective use of metallic bellows in new or unusual applications.

BELLOWS SEAL VALVES

the answer to industry's demand
for leakproof, maintenance-free valves for critical service



The advancing technology of the processing industries, plus the expanding demands of atomic energy, has radically changed valve design requirements. The increased handling of toxic and dangerous fluids has made leakproof valves mandatory. This same thinking applies equally to other types of equipment where an element in motion must be sealed. The result has been increased activity by designers in stem and shaft sealing projects.

Metallic Bellows Are the Economical Answer

Leading authorities agree that the metallic bellows seal is the answer to the problem. Flexonics is meeting this need today—economically, and in quantity production. The bellows are fabricated from a wide range of corrosion resistant metals. Leading valve manufacturers are applying this principle now. Bellows used in conjunction with conventional packing provide a safety feature without the maintenance problems of conventional packed valves.

FLEXON metal bellows can be supplied to meet virtually any condition of high temperature, high pressure and corrosive media. FLEXON bellows for these stem and shaft sealing requirements are available in stainless steel (321, 316 or 347), monel, inconel, brass and phosphor bronze.

The variety of valve types in which bellows may be used is limited only by the designer's imagination. The designs illustrated above are the kind commonly in use in industry today. The bellows is attached to a flange mounted between the valve body and bonnet. The stem of the valve is attached internally to the bottom plate of the bellows.

Engineering Assistance

As the pioneers of corrosion resistant bellows, Flexonics Corporation is well qualified to assist you in bellows seal valve design problems. All the know-how of over 18 years' experience in this specific field is at your disposal.

Whatever your bellows application problems, the Flexonics Application Engineering Staff will be pleased to assist you. For specific recommendations send us an outline of your requirements. For your bellows reference file, write for the Flexon Bellows Design Guide. For handy reference see the Flexonics catalog in Sweet's Product Design File.

B-47

BELLOWS DIVISION

Flexonics *Corporation*

1351 S. THIRD AVENUE • MAYWOOD, ILLINOIS
In Canada: Flexonics Corporation of Canada, Limited, Brampton, Ontario
Also Manufacturers of Rubber and Metal Hose Assemblies • Expansion Joints • Aircraft Components

these diagrams and formulas will help in . . .

GENEVA WHEEL DESIGN

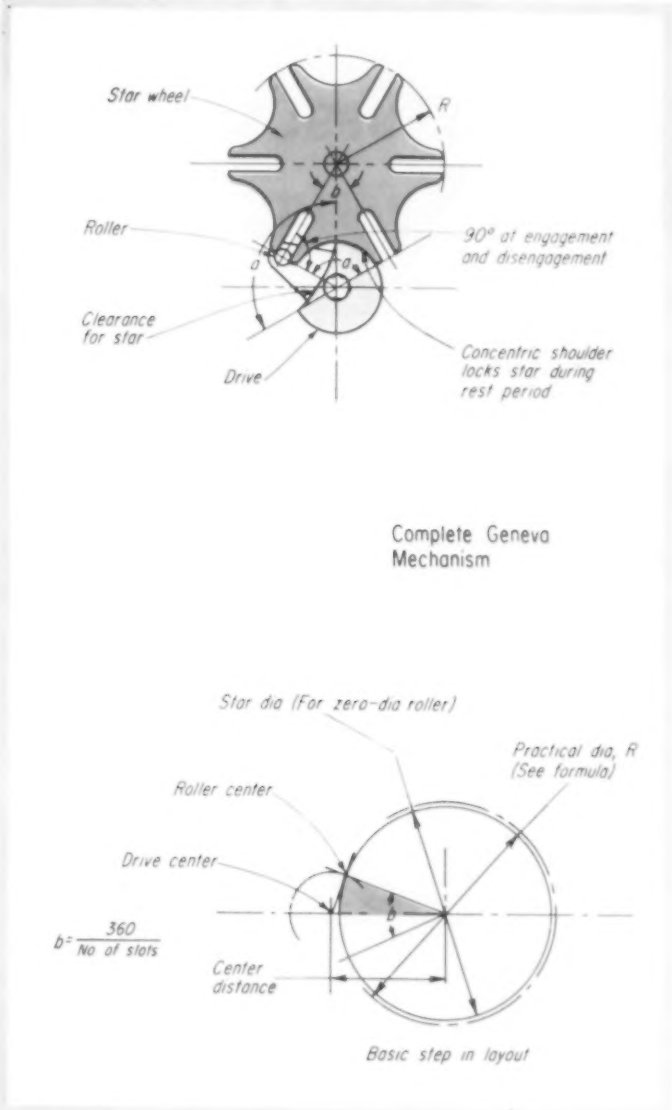
DOUGLAS C. GREENWOOD
Assistant Editor

The Geneva wheel was originally used as a stop for preventing overwind in watch springs—leave one of the slot positions unslotted and the number of turns the drive can make is limited. Now, the Geneva wheel is one of the most useful mechanisms for providing high-speed, intermittent, rotary motion.

In the position shown in the first diagram the roller is on the point of entering the slot and about to begin driving the star wheel. Drive ceases when the roller has moved through angle a. The star is locked during its rest periods because the concentric shoulder of the driving member has engaged the corresponding edge of the star. To permit the drive wheel to continue turning it must have a recess for star clearance.

When a Geneva mechanism is used in a machine, the machine speed depends upon the speed at which the star can be driven. Although, on balance, no advantage is gained, some modifications have been investigated that reduce the maximum acceleration and the resulting force. If, for example, the slots are not exactly tangential to the crank circle at their entrance, acceleration forces are reduced. Drive speed can, therefore, be increased. Such design changes, while decreasing acceleration, increase deceleration. Also, hammering will occur at the concentric surface, with a resultant noisy operation.

(Continued on page 85)



Geneva mechanism . . .

can theoretically have from 3 to any number of slots. In practice from 4 to 12 is enough to cover most requirements. Once the number of slots and crank dia are known, the layout can be started by constructing a right-angled triangle on the center distance. A tangent to the star dia where it is cut by a leg of the angle *b* is the crank radius. The clearance angle on the drive is 180 minus *b*. Layout is completed by drawing the rest of the mechanism outline. Roller and slot dimensions will depend on forces to which the mechanism will be subjected.

MULTI-FLEX

Which Multi-Flex application best solves your engineering problem ?

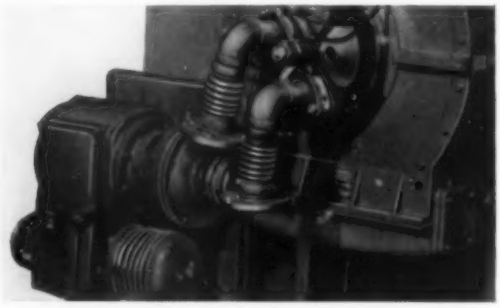
Here are just a few examples of the versatility that corrugated U. S. Multi-Flex® offers the equipment manufacturer.

Because Multi-Flex is specially engineered of rubber and fabric—*and not molded*—it has a built-in ruggedness that provides compression or extension without stretch or strain of the wall structure. It is available in a wide range of diameters and shapes, or can be engineered to your specifications. Inside diameters range from ¼" to 36", in constructions for service from minus 65 degrees to plus 500 degrees F.

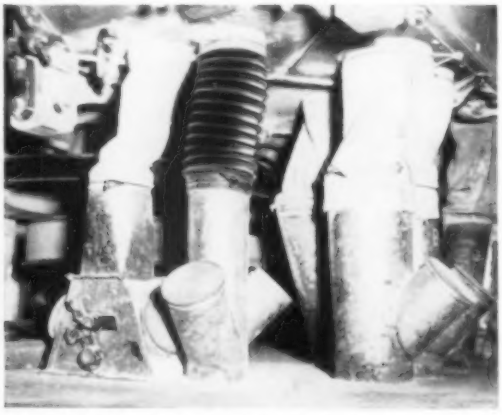
Get in touch with your "U.S." Distributor, any of the "U.S." Branch Offices, or contact us at Rockefeller Center, New York 20, N. Y. In Canada, Dominion Rubber Co., Ltd.

U. S. Multi-Flex is available in a wide range of diameters and shapes, or can be engineered to your specifications.

On this Dempster-Dumpster, Multi-Flex flat pleated sheet—acting as an accordion closure sealing an arc—combines a rubber-and-fabric strength to resist gouging and abrasion.



Multi-Flex connectors are used on this vacuum filter, taking care of axial movement and misalignment. They are especially valuable where conventional connectors will not take the required movement. Connectors can convey liquids, gases or granular solids.



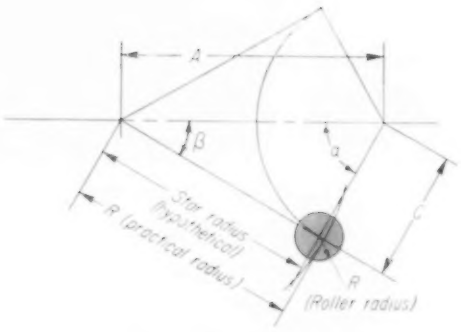
In this flour sifter, Multi-Flex boots function as sifter socks conveying sifted flour to the bin. Circular motion of the sifter requires extreme extendability of the socks. Multi-Flex solves this problem and far outlasts fabric socks.

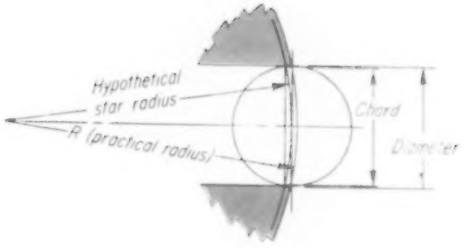
Mechanical Goods Division

United States Rubber

See things you never saw before. Visit U. S. Rubber's New Exhibit Hall, Rockefeller Center, N.Y.

GENEVA WHEEL DESIGN





DESIGN FORMULAS

Values such as angular position at any instant, velocity, acceleration and practical star-wheel dia can be calculated from the formulas that follow. Illustrated in the sketch above are symbols that appear in the formulas.

Center distance A

$$= CM \text{ where } M = \frac{1}{\text{Sin}\,\frac{180}{\text{no. of slots}}}$$

Angular displacement:

$$\text{Tan}\ \beta = \frac{\text{Sin}\ \alpha}{M - \cos\alpha}$$

Angular velocity

$$= \frac{d\beta}{dt}$$

$$= \omega\left(\frac{M\cos\alpha - 1}{1 + M^2 - 2M\cos\alpha}\right)$$

where Ω = radians/sec

Angular acceleration, radians/sec²

$$= \frac{d^2\beta}{dt^2}$$

$$= \omega^2\left(\frac{M\sin\alpha\,(1 - M^2)}{(1 + M^2 - 2M\cos\alpha)^2}\right)$$

Max acceleration occurs when

$$\cos\alpha = \pm\sqrt{\left[\left(\frac{1 + M^2}{4M}\right)^2 + 2\right]} - \left(\frac{1 + M^2}{4M}\right)$$

Max acceleration and therefore max wear occurs at about ¼ to ¼ distance down the slot length from the wheel edge.

Practical star-wheel dia

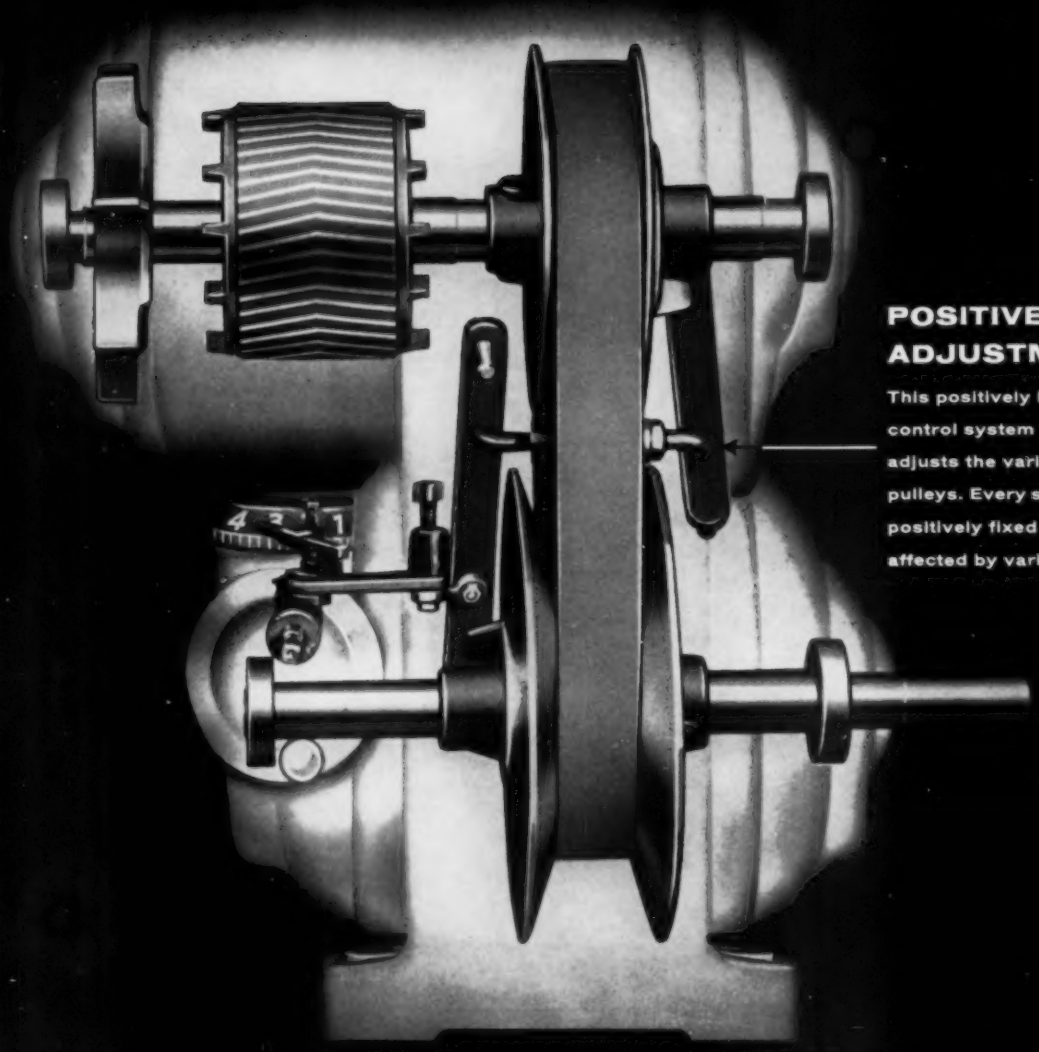
$$2R = \sqrt{A^2 - C^2 + \mu^2}$$

Hypothetical star radius . . .

would be practical only for a roller of zero dia. Otherwise *R* will always be the greater radius. This ensures that correct roller and slot clearance is maintained at entrance and exit. Difference between chord and dia would be the excess clearance that would result (at time of entry and exit) from using incorrect radius.

ANGULAR DISPLACEMENT OF DRIVE
during periods of star-wheel rest and motion

Slot angle	No. of drive rollers	Drive crank: Degrees of driving stroke (motion period)	Drive crank: Degrees of free turning (dwell period)
90° 4 slot	1	90	270
	2	180	180
	3	270	90
	4	360	0
72° 5 slot	1	108	252
	2	216	144
	3	324	36
60° 6 slot	1	120	240
	2	240	120
45° 8 slot	1	135	225
	2	270	90
36° 10 slot	1	144	216
	2	288	72
30° 12 slot	1	150	210
	2	300	60



POSITIVE PULLEY ADJUSTMENT

This positively linked speed control system reciprocally adjusts the variable pitch pulleys. Every speed setting is positively fixed and is not affected by variations in load.

New Worthington motor drive gives you

ACCURATE SPEED REGARDLESS OF LOAD

Once you set the speed on a Worthington variable speed motor drive, the pulley holds it – maintaining accurate speed control regardless of variations in load.

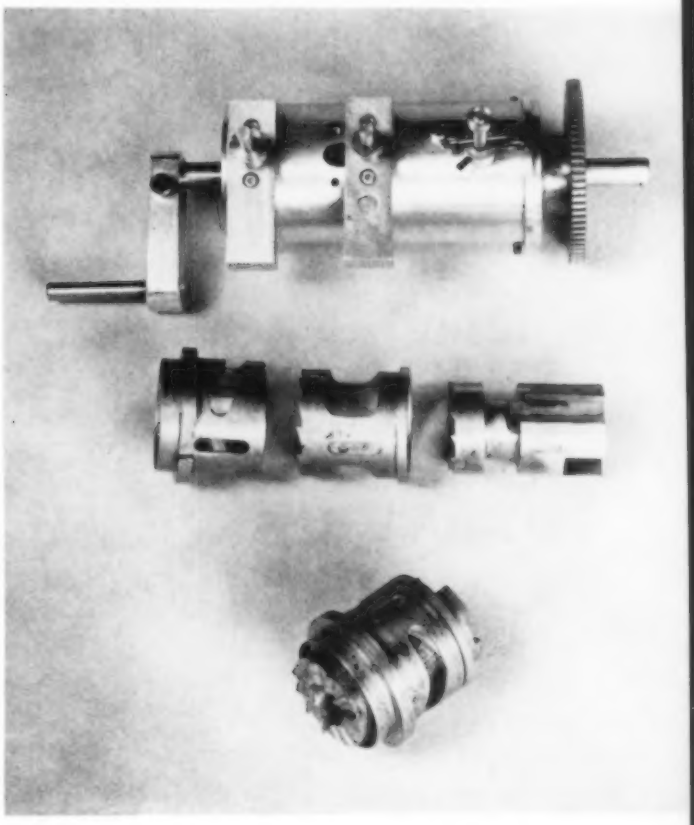
This unique feature is the result of "positive pulley adjustment." A positively-linked speed control system reciprocally adjusts the variable pitch pulleys. Unlike spring-equipped drives which constantly maintain maximum belt tension to meet occasional peak loads, belt tensions in a Worthington drive never exceed the actual load transmitted. Peak and momentary starting loads are transmitted just as smoothly as they would be with a standard fixed speed V-belt drive.

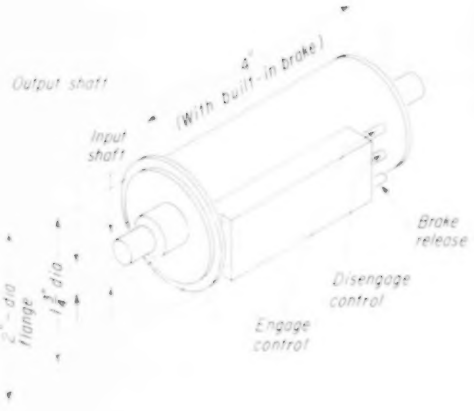
Positive pulley adjustment also results in a compact design with inherently long belt life. The wide-angle design of the belt offers deep side walls for greater contact area. This feature gives you high power capacity with minimum belt pressure. The large diameter pulleys assure smooth, efficient operation with little wear.

The new line is available in speed variations up to 10:1 and horsepower ratings from ½ to 25 hp. You can specify finger tip speed control or one of the many types of remote controls – both automatic and mechanical. For complete information, write for Bulletin 1610-B1. Address Section MV-78, Worthington Corporation, Oil City, Pa.

WORTHINGTON

NEW COMPONENTS and MATERIALS





Clutch Disengages at Predetermined Position

This clutch is disengaged by the driver at a predetermined position regardless of load or speed. It may be operated automatically or as a manual on-off type. Its prime use is as a single-revolution clutch, but it can also be used as a random disengaging mechanism. The device consists of an engaging sleeve containing a disengaging sleeve inside, and a driven element or spool.

Operating cycle begins with lifting of latch, which allows spring to rotate engaging sleeve. This slides spool into engagement with driver, with disengaging sleeve remaining in neutral. When pawl comes around, it causes disengaging sleeve to move into contact with driver, which then rotates both sleeves. This rotation disengages spool and disengaging sleeve, allowing latch to drop in front of shoulder, ready for next cycle.

A brake may be incorporated if desired. In operation, the brake is applied automatically by positioning of the spool when retracted from engagement with driver. Brake is released with engagement of spool. A wet-plate brake is shown, but any type may be used.

Controls are all external to case. Latch may be pulled mechanically or by solenoid. Shoe may be moved either mechanically, manually or by solenoid. Latch and shoe may also be coupled to produce one instead of two controls.

Clutch may be used in mechanisms requiring exact indexing with no danger of creep, overrunning, or hammering. Size varies with capacity but is suitable for punch presses, and machinery such as that used in duplicating, packaging, coil-winding.

Clutch shown is available with $\frac{3}{4}$ and $\frac{1}{2}$-in. shaft, with clockwise rotation (viewed from input end). Counter-clockwise operation is also possible, and other sizes can be had. It has a capacity of 10 ft-lb and is designed for heavy duty with continuous, long life. Present model is available from stock, about $50-$60; in quantity production, about $10. **Tickamatic Corp., 18 Franklin Ave., Port Washington, N. Y.**

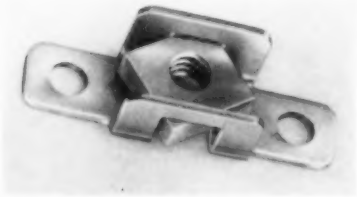
Circle 1, inside back cover

. . . CONTINUED ON PAGE 88

High-temperature bearing . . .

is carried in stock in four sizes: 200, 202, 204 and 206. Suitable for operation in ambient temperatures to 900 F. Inner and outer races are high-speed steel. The riveted machined retainer is land riding and is manufactured from S-Monel or heat-treated steel. Bearings operate at speeds to 40,000 rpm without lubrication. **Industrial Tectonics, Inc., 3686 Jackson Rd., Ann Arbor, Mich.**

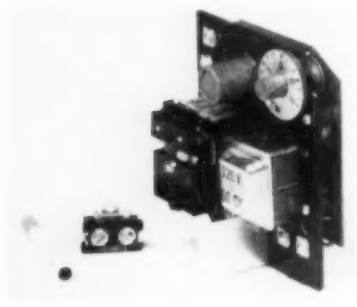
Circle 2, inside back cover



Captive nut assembly . . .

comes in all standard sizes. Nut is permanently held within cadmium-plated steel bracket. **Raytheon Mfg. Co., Commercial Equipment Div., 100 River St., Waltham, Mass.**

Circle 3, inside back cover



Remote temperature control . . .

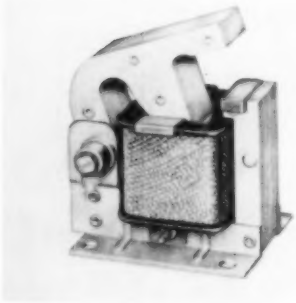
for air, surface or immersion temperatures consists of a transistor-equipped amplifier and a mounting. Latter contains a thermistor that acts as sensing element. Mounting and amplifier can be located as much as 2 mi apart. Mountings, as small as $\frac{3}{32}$ in. dia x 2 in. long, are available in sizes and shapes to fit any application. Amplifier relays are available in eight overlapping ranges of about 100 F to permit control from −60 to 520 F. Can be used with a variety of heat sensing units. UL-listed system is priced at $59.50. **Minneapolis-Honeywell Regulator Co., Control Device Div., 2747 Fourth Ave. S., Minneapolis.**

Circle 4, inside back cover

Right-angle swivel fittings . . .

afford low torque under all operating conditions. Said to have low pressure drop and no leakage, with 360°-positioning possible. Swivels conform to or exceed applicable military specs. Available in $\frac{3}{8}$ to $\frac{1}{2}$-in. tube sizes. Operating pressure is 3000 psi. For temperatures from −65 to 300 F. **Altair, Inc., 50 MacQuesten Pkwy. S., Mount Vernon, N. Y.**

Circle 5, inside back cover



Rotary action solenoid . . .

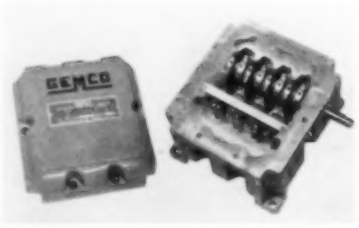
operates in minimum space and motion is delivered by shaft rotating at point of pivot. Shaft, the only moving part, is hinged and held to one path without external attachments. An F-shaped plunger that rotates about an axis perpendicular to coil centerline creates a wider arc of travel. Required action may be obtained by direct attachment to shaft or rotor, and motion may be clockwise or counterclockwise. Can be energized in ac operation for continuous or intermittent duty. It is equipped with a thermal device. Sizes range from 2-oz-in. starting torque to 150 in.-lb. **Roto Mfg. Co., Xenia, Ohio.**

Circle 6, inside back cover

Aluminum-bronze alloy . . .

is for applications where stress corrosion cracking formerly prevented such use. It is said to be particularly applicable in the vapor phase of various corrosive media. Alloy has eliminated need for stress relief in all finished fabrications to guard against stress corrosion cracking, and alterations or repairs can now be made without heat treatment. Material, which has been modified from the original by adding 0.35% of tin or silver, is permitted in construction of ASME-approved pressure vessels and can be used to 500 F with an allowable working stress of 10,000 psi. **Ampco Metal, Inc., 1745 S. 38th St., Milwaukee.**

Circle 7, inside back cover



Rotating-cam limit switch . . .

can be adjusted to meet all requirements by loosening a screw and rotating cams relative to each other to desired position. A continuous range of an open and closed circuit can be obtained from 360° to about 8°. The explosionproof switch has speed rating of up to 400 rpm. SPDT switch contacts are rated 15 amp at 115 v and 5 amp at 440 v. Circuits are electrically separate. NEMA type 7 enclosure is cast aluminum or cast iron. Also offered in NEMA type 1, 4, 5, and 12 enclosures, 2 through 12 circuits, high and low speeds. **Gemco Electric Co., 25685 W. Eight Mile Rd., Detroit 40.**

Circle 8, inside back cover

Hydraulic accumulator . . .

uses a fail-safe, free-moving float to separate operating fluid and gas under pressure, and to operate a valve that retains residual fluid and gas when unit's capacity is exceeded. Conventionally, separators are rubber diaphragms and bladders, which

. . . CONTINUED ON PAGE 90

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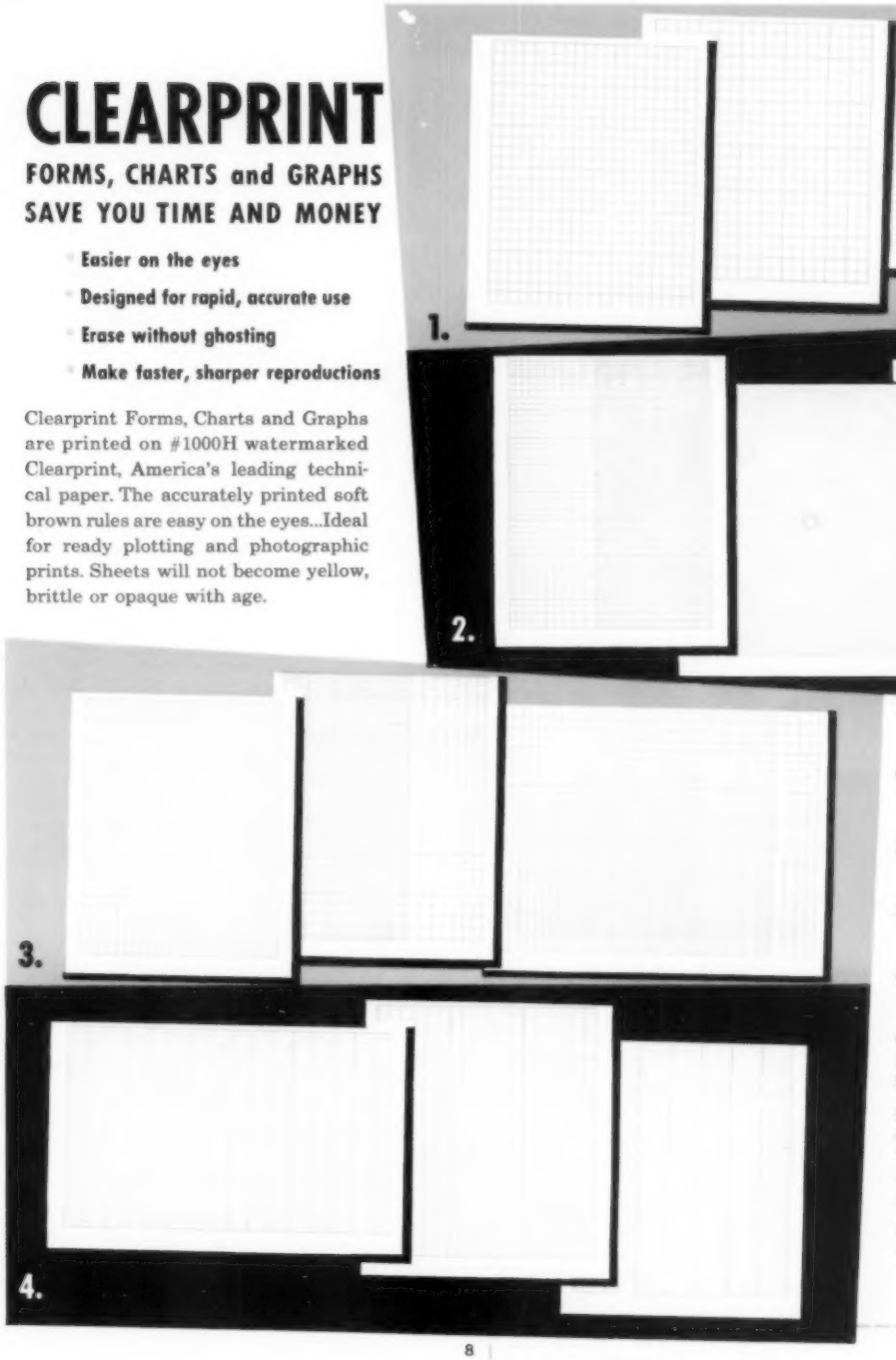

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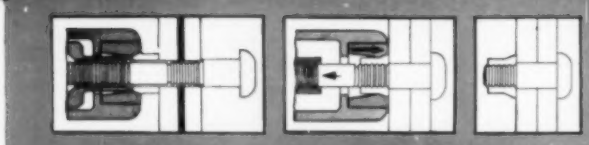

Pin is inserted and collar placed on bolt, gun then engages pull grooves, draws material together and pulls pin into hole. Collar is swaged into locking grooves and pin tail then is broken off at breaknock groove. Action takes place in the time it takes to pull trigger.

This quick demonstration at your desk will show how to get superior, more economical fastening with TOWNSEND LOCKBOLTS*

In a few minutes we can show how Townsend lockbolts will give you superior fastening at lower installed cost and improve your products. A Townsend engineer will demonstrate the ease with which they can be installed, and prove their high resistance to vibration and shock.

Townsend lockbolts provide a higher clinch, or clamping action than rivets, and more uniform fastening than nuts and bolts. They fill the hole better than other fasteners, have high tensile pre-load, make a more rigid joint and provide an effective liquid seal. Available in both steel and aluminum alloy in a variety of diameters and lengths—two head styles.

For a demonstration of how Townsend lockbolts will improve your fastening while lowering the cost, write to Townsend Company, P.O. Box 237-D, New Brighton, Pa.

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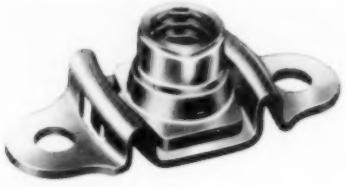
require frequent replacement and are subject to failure; or pistons, which may stick. In this accumulator, pre-charge pressure is retained when float at low position triggers a positive shut-off valve. Reports indicate that 3% of operating fluid that is exposed to gas around the float is not detrimental to operating efficiency. Built in sizes from 1 to 20 gal. with working pressure to 3000 psi max. Multiple units may be used for larger volumes. **Payne Mfg. Co., 7317 Canal St., P.O. Box 9278, Houston.**

Circle 9, inside back cover



Replaceable nut element . . .

is the basis of a line of self-locking plate nuts now being produced in all popular base styles and thread sizes. It aids alignment problems and is reported to save production time by eliminating setup screws or accurate holding devices during location and riveting. Retainers may be installed first and nuts snapped into place after painting, if necessary. **Nutt-Shel Co., Inc., 811 Airway, Glendale 1, Calif.**

Circle 10, inside back cover

Linear-motion potentiometer . . .

has self-aligning shaft which permits measurement of linear displacement even where perfect alignment with actuating member is impossible. Design is said to eliminate side loads on the shaft and

(Continued on page 94)

advertisement

air circuitry:

a sales tool for you—Air is booming as an industrial control medium. Air Circuitry* has recently been applied to jobs where it never would have been considered a few years ago! Westinghouse pneumatic engineers have designed and installed Air Circuitry systems for original equipment which have boosted production and cut time and labor expenses for a wide variety of industries including electronics, textiles, automobiles, chemicals, and aircraft.

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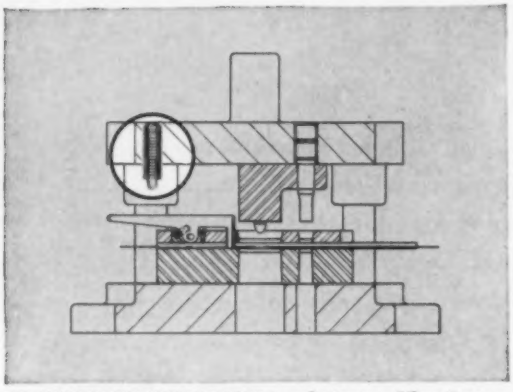
*AIR CIRCUITRY is the Westinghouse term for application of pneumatic control systems to industrial production operations.

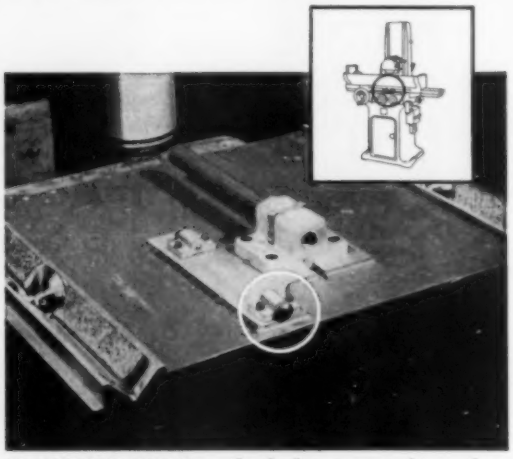
Practical Design Tips

Number 2 of a series.

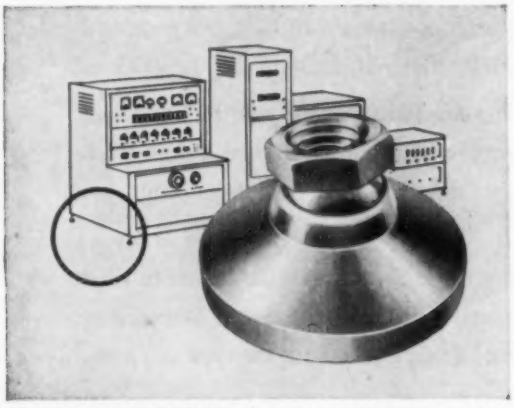
Substituting simple, off-the-shelf Vlier Tooling Accessories for complicated, custom-made devices in both tooling and original equipment applications can result in important savings. Why not put them to work in your plant?



TO STOP SMASHING DIE STOPS, substitute a Vlier Spring Plunger for the usual square-head screw. The plunger actuates the automatic stop perfectly and, unlike the screw, never needs adjusting no matter how many times the die is resharpened. Available in four models: 50 sizes.



TO CUSHION SHOCK as the bed traverses, this surface grinder manufacturer uses two Vlier Spring Stops, reducing wear and tear on the machine. These clever, spring-loaded devices, ordinarily used on fixtures where the absence of side walls prevents the use of spring plungers, are now available in three standard sizes: 3 end pressures. Special sizes made to quantity orders.



TO LEVEL MACHINE TOOLS, electronic racks, benches, etc., use the *standard* Vlier leveling pad. The pad swivels to 7½° each side of the center line; adjusts automatically to uneven surfaces. Unique ball-joint design distributes weight over entire pad surface.

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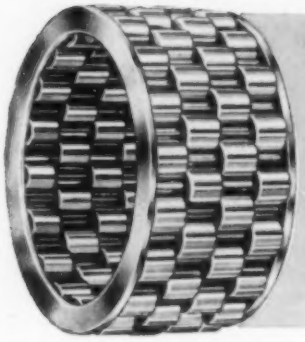
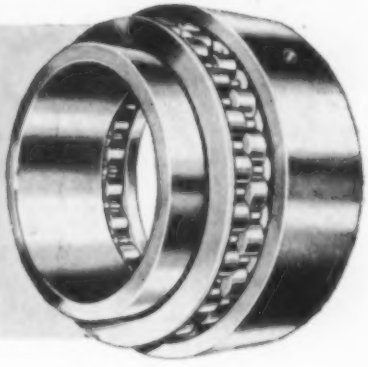
Why ORANGE *STAGGERED* ROLLER BEARINGS

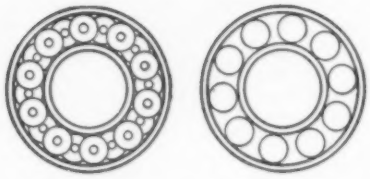
carry heavier loads--run more smoothly--provide longer life



STAGGERED ROLLER DESIGN

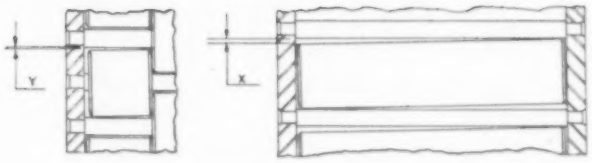
By using many short rollers in staggered arrangement instead of fewer long rollers as in conventional bearings, Orange "Staggered" Roller Bearings provide outstanding advantages for heavy-duty, highly-stressed and precision applications. They do the work of larger straight roller bearings—save space, weight and cost—assure long, trouble-free operation.





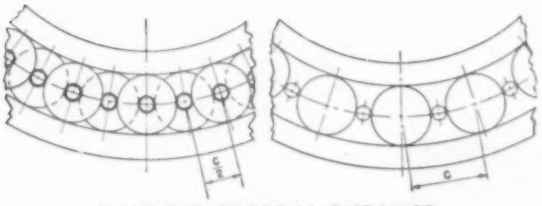
MORE ROLLERS SUPPORT THE LOAD

End views of "Staggered" roller bearing (left) and conventional bearing, show how many short rollers distribute the load over a multiplicity of contact points within the loaded zone.



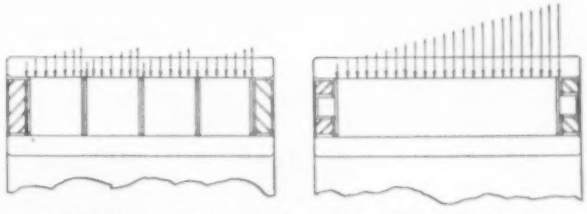
GREATLY REDUCED ROLLER SKEWING

For a given angular misalignment, a short roller tends to skew only a fraction that a long roller will skew. Each row of rollers aligns itself independently, whereas a long roller has the tendency to skew along its full length.



HALF THE CHORDAL DISTANCE

Staggered rollers, with closer centers, provide a much smoother running bearing. This is especially beneficial when rolling sheet or foil, and provides better tone in rotogravure printing applications. More pins add greater rigidity to the cage.



REDUCED EDGE LOADING—BETTER FATIGUE LIFE

Dimensional deviations of component parts or uneven loading cause edge loading of rollers. Illustration shows greatly reduced effect on short staggered rollers compared with long straight rollers.

Available in a complete range of sizes interchangeable with other bearings in the 200 and 300 series.

WRITE for 40-page Engineering Reference Manual giving full specifications of "Staggered" Roller Bearings and other Orange Roller Bearings.

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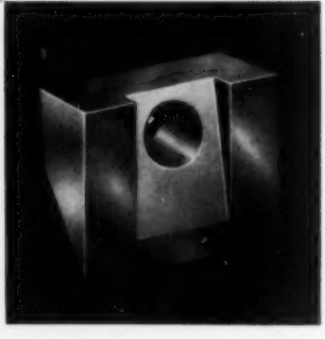

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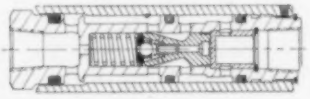
simplifies instrument installation. Available with travel shaft ranging from ½ to 6½ in. Single or dual potentiometer outputs are available, in resistance values of 1, 2, 5, 10, 20, and 50 k. Acceleration error is less than resolution at 100 G, without noise. **Bourns Laboratories, Inc., P. O. Box 2112, Riverside, Calif.**

Circle 11, inside back cover



Pressure-compensated valve . . . for in-line use is adjustable. Changes in flow rate are made by rotating valve sleeve. Settings are accurate within 5 to 15% Sleeve calibrations facilitate repeat flow settings without tedious adjusting. A built-in check valve provides free flow in noncompensated direction. Operating pressure is 3000 psi max. Available in ¼, ⅜ and ½-in. pipe sizes for flow rates to 5, 10 and 18 gpm, respectively, for immediate delivery. **Fluid Power Accessories, Inc., P. O. Box 64, Glenview, Ill.**

Circle 12, inside back cover

Welding dissimilar metals . . . automatically or manually in 95% of all combinations in inert gas welding field has been facilitated by development of a bare filler wire. Welds produced are said to have high strength and are suited to sub-zero, room and elevated-temperature applications. Wire operates in all positions; leaves a high-strength, corrosion-resistant deposit; and has good machinability. Wire deposit has high impact resistance and, therefore, is suitable for overlay applications. Deposit is age-hardenable. Available as 36-in. lengths in $\frac{1}{16}$, $\frac{3}{32}$, $\frac{1}{8}$ and $\frac{5}{32}$ in. dia and on spools in 0.035, 0.045 and 0.062 in. dia. A metal arc welding electrode for applying a hard protective surface to low alloy steels or cast irons that are subject to severe abrasive conditions has also been introduced. Overlay is structurally similar to Ni-Hard nickel-chromium alloy and has same degree of hardness and abrasion-resistance. Electrode has smooth arcing characteristics and is operable in all positions. It is used under typical hard-surfacing conditions, usually requiring that interbead temperature be held at or below 200F and requiring two layers of hard-surfacing material. Preliminary field tests of the deposit on mold steel showed a hardness of 650 to 700 Brinell for the two layers. Available in $\frac{3}{32}$, $\frac{1}{16}$ and $\frac{1}{4}$ in. dia. An important aspect of both products is their use for joining of 9% nickel steel, a material with properties that make it especially suitable for low-temperature applications to about

(Continued on page 96)

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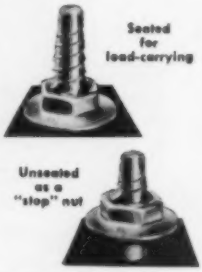
PALNUT SELF-THREADING LOCK NUTS

Form deep, clean threads on unthreaded studs or rod while tightening. Provide vibration-proof grip on studs, whether seated for load-carrying, or unseated as a "stop" nut. Adequate prevailing torque keeps nut in position. Hex form fits all standard tools for easy fast assembly. Washer base spans holes and slots. Also available with sealer washer. May be removed and re-used. Sizes for 1/8", 3/16" and 1/4" dia. rod or studs.



Type C (closed end)

PUSHNUT® FASTENERS -- ACORN TYPE

Simply push or tap on unthreaded rod, wire or rivets to lock securely. Saves threading, notching or drilling for cotter pins. Locking grip at base resists removal. Smooth contour of Acorn Type C covers rod ends. Type CK has open end, assembles with rod end flush with PALNUT. Six sizes from .120" to .312" dia. rod or wire.

Type CK (open end)

PUSHNUT® FASTENERS -- FLAT TYPE H

Quickly push on unthreaded studs, rod or rivets to provide tight, rattleproof assemblies. Four gripping teeth, long spring arch, turned up edges assure full seating and resilient grip, even on hard chrome studs. Fast assembly with PALNUT applicators. Sizes for 1/16", 3/32" and 1/8" dia. studs.

PUSHNUT® FASTENERS -- TYPE W

Made of heavy gauge, tempered spring steel with powerful gripping action when pushed on unthreaded rod or axles. Will not cock, misalign or deform in assembly. One-piece construction. Removal forces from 100 to 1,000 lbs., according to size. Available for 3/16" 3/8" and 7/16" rod.

Write for free samples, stating type, size and intended application.

THE PALNUT COMPANY, 65 Glen Road, Mountainside, N. J.
In Canada: P. L. Robertson Co., Ltd., Milton, Ont.

PALNUT® LOCK NUTS FASTENERS PAL®

Quick, secure fastening at low cost

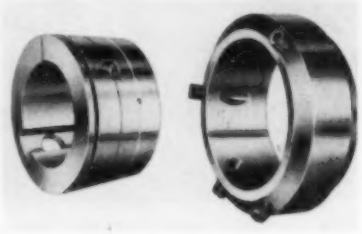
—310 F. Internatoinal Nickel Co., Inc., 67 Wall St., New York 5.

Circle 13, inside back cover

Key-operated plug . . .

prevents entrance of plug into electrical outlet in locked position. Locking mechanism projects a nylon safety bar. Bar is retracted by turning key to unlocked position. UL-approved plug eliminates hazards of accidental or unauthorized use of electrical appliances and power tools. Retails for about $1.75. **Yale & Towne Mfg. Co., Chrysler Bldg., New York 17.**

Circle 14, inside back cover



All-steel hub . . .

for assembly of sprockets, pulleys, sheaves, gears, couplings and other industrial equipment is adaptable to various shaft assemblies without increasing over-all length of product itself. When used with a companion steel split tapered bushing, only a hexagonal head key is needed for installation or removal. Alloy steel compression setscrews mount flush with hub surface. Hubs range in size from 2.875 to 8 in. OD and each hub will accommodate bushings with varying bore sizes. List prices range from $4.50 to $54 each. **Cullman Wheel Co., 1344 Altgeld St., Chicago 14.**

Circle 15, inside back cover

Numbered indicating lights . . .

have lenses made from solid metal disks which may be oriented after installation. Subminiature high-temperature units are available in 55 mounting configurations and body types and with lenses to fit

(Continued on page 101)

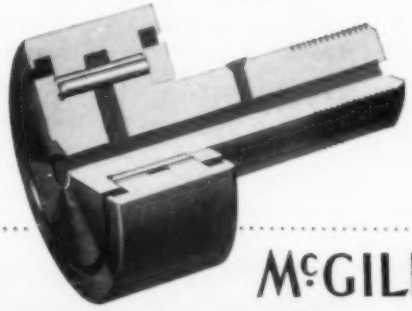
only McGILL® sealed *CAMROL*® cam followers give you . . .

effective sealing

prelubrication

high radial and shock capacity

in a full range of sizes



Effective sealing of the CAMROL cam follower against moisture, dirt, chips, etc. guarantees longer service life . . . reduces maintenance. This sealed construction retains lubricant and eliminates need for frequent relubrication, so often undesirable in cam action, guide support and track roller applications.

Special seals are built in at stud and flange ends. A black oxide finish on all exposed surfaces offers outside corrosion resistance. The channeled reservoir above the rollers in the outer raceway bore helps store reserve lubricant, sufficient in most cases for lifetime service. Relubrication is possible through convenient oil holes. The new SCF sealed CAMROL cam followers interchange with proven standard CAMROL cam followers. Standard stock with roll diameters up to 4″ are available for both stud and shaft mounting.

For maximum bearing life where contamination is a problem, specify sealed CAMROL cam followers. Ask your McGill representative or our engineering department for recommendations.

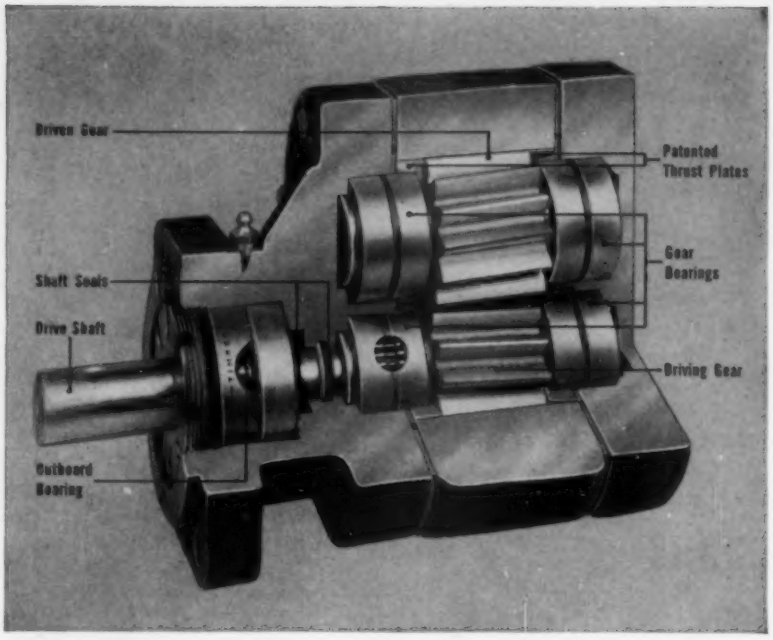
Write for Catalog No. 52-A

McGILL®

MULTIROL® GUIDEROL® CAMROL®
Precision Needle Bearings

McGILL MANUFACTURING COMPANY, INC., 201 N. LAFAYETTE ST., VALPARAISO, INDIANA

ADVANCES IN HYDRAULIC PUMP DESIGN



Oil leakage controlled

In any method of mounting an oil-hydraulic pump there is always a certain amount of misalignment between the pump drive shaft and the shaft on the power source. Even where universal drives are utilized there is still the danger of a thrust load. Result in both cases: Flexing is transmitted into the pump seal and eventually to the bearings supporting the gear—leakage around the shaft is a sure-fire bet to follow.

At Commercial, by using an outboard bearing to protect the seals and internal bearings, the common leakage nuisance is eliminated.

Internal alignment perfected

Mass production of independent gear pump housing parts invariably results in varying degrees of internal misalignment—regardless of dowel pin control points used in machining. In many cases the "out" for the problem involves a loosening up on the internal tolerances—with a resultant loss in efficiency.

At Commercial, the patented thrust plate serves as a "natural" alignment control point—is counter bored on its face to match the bearing sleeve, then fits over the bearing sleeve and in turn pilots inside the gear housing. Perfect internal alignment—and increased efficiency—in any Commercial oil-hydraulic pump is axiomatic with rigid inspection of the thrust plate alone.

Constant volume assured

The principle of automatic adjustment of end clearance by internal pump pressure had one main weakness. The full pump pressure was applied against the whole area of each thrust plate. The plates would wear unevenly because on the inlet side of the pump the plate had full pump pressure on one face and a vacuum on the gear side.

By "pressure pocketing" Commercial insured that the pressures on opposite faces of the thrust plates would be in approximate balance around the entire area of the plate faces. Commercial's "one-two" advance design punch—the patented "pressure pocketed" thrust plate—assures constant volume at any pressure and at the same time helps to maintain simplicity of design and soundness of construction . . . provides for longer operating life and no maintenance headaches.

Seizing eliminated

Commercial oil-hydraulic pumps cannot seize because of heat induced by high speed or even inadequately piped systems. Variable end clearance and positive internal alignment make seizing practically impossible. Bearings evenly loaded throughout their length—no corner loading or spawling—are able to withstand much higher operating pressures. They stay in service longer too—regardless of pressures involved.

To take full advantage of tight internal tolerances Commercial designs, produces and grinds its own rotating gears—is able to hold extra close tolerances on tooth contours, outside diameters, and concentricity.

Over 5,000 different pump combinations—port locations and sizes—can be built from Commercial's standard line of oil-hydraulic pump components. A wide variety of drive shafts and mounting combinations are available to solve virtually any individual installation, piping and power application requirement.

Engineering help available

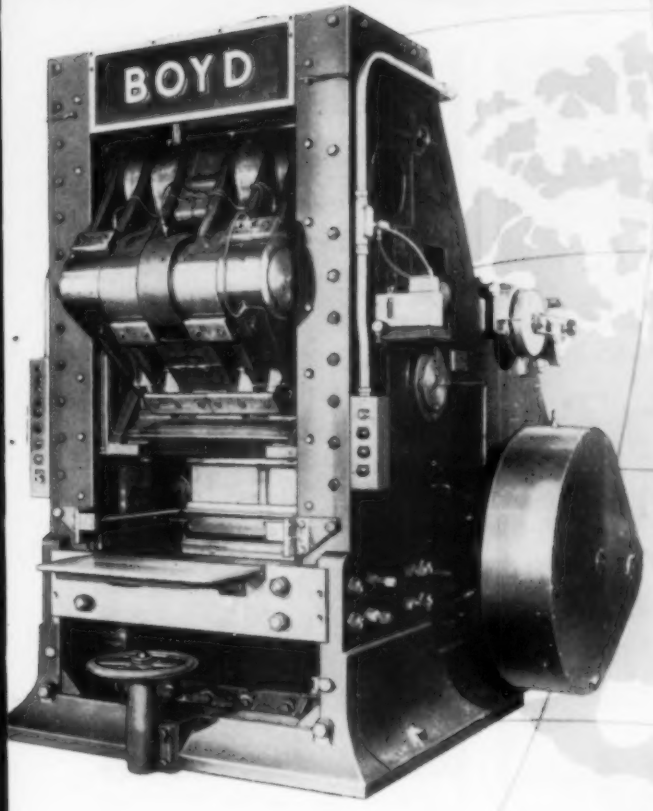
Commercial's oil-hydraulic pump engineering advances are typical of its complete line of oil-hydraulic equipment. The solid technical help Commercial sales engineers can contribute on the application of oil-hydraulic pumps, motors, cylinders and valves may be able to help cut your costs and improve performance.

ENGINEERING DATA FREE

For more information write to Dept. G-22, Commercial Shearing and Stamping Company, Youngstown 1, Ohio. Better yet, send for your copies of Commercial's free engineering reference bulletins. Just check the items below in which you are interested.

- ☐ "Complete Oil-Hydraulic Line Catalog H-7"
- ☐ "Oil-Hydraulic Pumps and Motors Catalog H-4"
- ☐ "Performance Rated Oil-Hydraulic Valves Catalog H-12"
- ☐ "Oil-Hydraulic Cylinders Catalog H-3"

COMMERCIAL
shearing and stamping



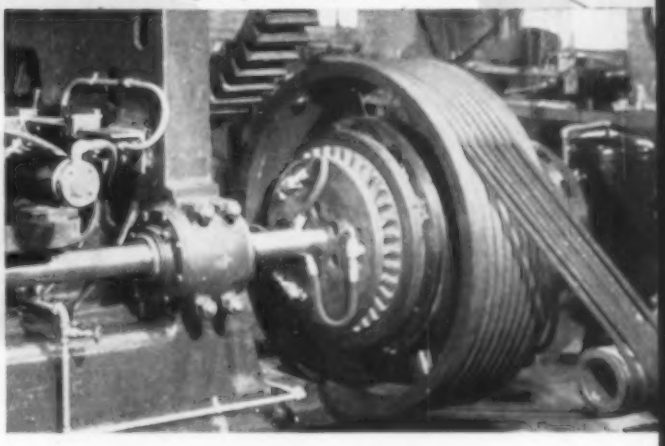
"WICHITA Clutches and Brakes *Opened New Markets . . .*"

States

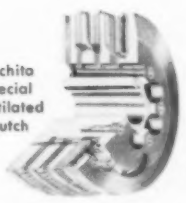
R. A. Ebersole, Vice President
Chisholm, Boyd & White
Chicago, Ill.

(World's largest producers of Brick Presses.)

"By allowing us to introduce a flexibility of controls into our presses, which was heretofore impossible, Wichita Clutches and Brakes have allowed us to invade new markets. We are very well satisfied with the service the Wichita Clutch and Brake system gives us and find that many new sales have materialized because of the practically non-existant maintenance of this system. We have found the Wichita Clutches and Brakes to be extremely well engineered, sturdily built and capable of taking the roughest of treatment."



Above is a close-up of the Wichita Clutch mounting.



Wichita Special Ventilated Clutch

Wichita Low Inertia-Air Set Brake

Let WICHITA CLUTCHES & BRAKES help you open new markets . . . Consult a Wichita Engineer!

WICHITA Clutch COMPANY, INC.
WICHITA FALLS, TEXAS, U.S.A.

Contact your nearest Wichita Engineer!

Brehm-Lahner, Inc., Detroit, Michigan
L. H. Fremont, Cincinnati, Ohio
W. G. Kerr Company, Pittsburgh, Pa.
Smith-Keser & Co., Avon, Conn., Philadelphia 44, Pa., and New York, N. Y.
Frank W. Yarline Co., Chicago, Illinois
Larry W. McDowell, Long Beach, California
Andrew T. Lobel, Denver, Colorado
Robert R. King Co., Cleveland, Ohio
Norman Williams, Houston, Texas
Allied Transmission Equipment Co., Kansas City 8, Missouri
Donald E. Harman, Dallas, Texas
C. Arthur Weaver, Richmond, Virginia
Malcolm S. Cone, Memphis, Tennessee
Dominion Power Press Equipment, Ltd., Burlington, Ontario, Canada
R. E. Kunz, Seattle 4, Wash.
W. G. Ballantyne Co., Portland 4, Ore.
Bates Sales Co., St. Louis 1, Mo.

BEAVER BALL SCREWS

PROVIDE THE ACCURATE POSITIONING ESSENTIAL FOR NUMERICAL CONTROL

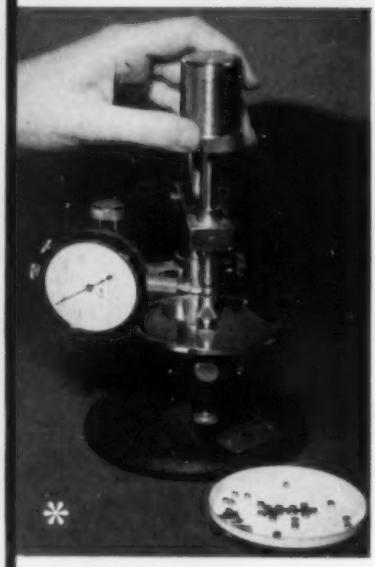
Beaver Precision ball lead screws on all three axes provide the basic measuring and actuating elements which simplify the design of this tape controlled milling machine.

Beaver ball screws move table of this Bridgeport Mill in response to signals from the Electronic Control Systems, Inc. "Digimatic" control and are typical of those now in use on numerically controlled machine tools of all types.

If it's numerically controlled, tape or card, it is more than likely equipped with Beaver ball screws. Our engineers are available to you for consultation – can we help you improve the design of your equipment?

Beaver Precision Products INC.
CLAWSON, MICH.

There's a *Bird* JEWEL BEARING to fit Your Need!



Bird can supply you with sapphire and borrosilicate glass precision jewel bearings in a wide range of standard types, sizes, and complete assemblies — or, custom-built to your specifications. Special mounting techniques provide exact tolerance jewel assemblies, mounted or set in bushings or screws, ready for assembling into your product without further inspection. Jewels mounted with resilient silicone rubber or spring cushions provide additional protection to shock and vibration.

Because of the exact tolerances, maintained through the most rigid quality-control methods, Bird jewels are used by the foremost manufacturers of electrical, aircraft, and timing instruments — and recorders.

Typical products include:

Aircraft Instruments
Weather Recorders
Ammeters
Voltmeters
Wattmeters
Compasses
Dial Gages
Timers
Test & Recording Instruments
Marine Instruments

**Illustrated — Concentricity check of mounted ring jewels — one of the inspection processes in Bird's quality control program.*

Our engineering staff is at your service for all small bearing problems. A request on your letterhead for Bulletin 100-6 will receive our prompt attention.

Richard H. Bird & CO., INC.
1 SPRUCE ST., WALTHAM 54, MASS.

SAPPHIRE & GLASS JEWELS
PRECISION GLASS GRINDING
JEWEL MOUNTING & ASSEMBLY

most applications. Incandescent lights, with numbers, may be secured in place in the manner of unnumbered lights. Most models offer 180° visibility. All models have nylon coding collars in standard RETMA colors behind panel to simplify wiring. **Sloan Co., 4101 Burbank Blvd., Burbank, Calif.**

Circle 16, Inside Back Cover

Foot, knee, elbow switch . . .

permits hand-free actuation of electrically operated mechanisms. Foot operation requires 4 lb pressure with ½-in. total pedal travel. Non-skid rubber feet prevent slipping. Knee or elbow operation requires removal of a spring to permit actuation with lighter pressure. For industrial service, the unit switches ¾-hp loads at 115 v ac. SPST normally open and normally closed switches are furnished only without cord. For use in dry, clean areas, the housing is die-cast aluminum. Dimensions are 2¾ x 6 x 1⅝ in. high. Weight, 1 lb. **Production Instruments Div., General Controls Co., 8072 PH McCormick Blvd., Skokie, Ill.**

Circle 17, Inside Back Cover

Miniature cylinder . . .

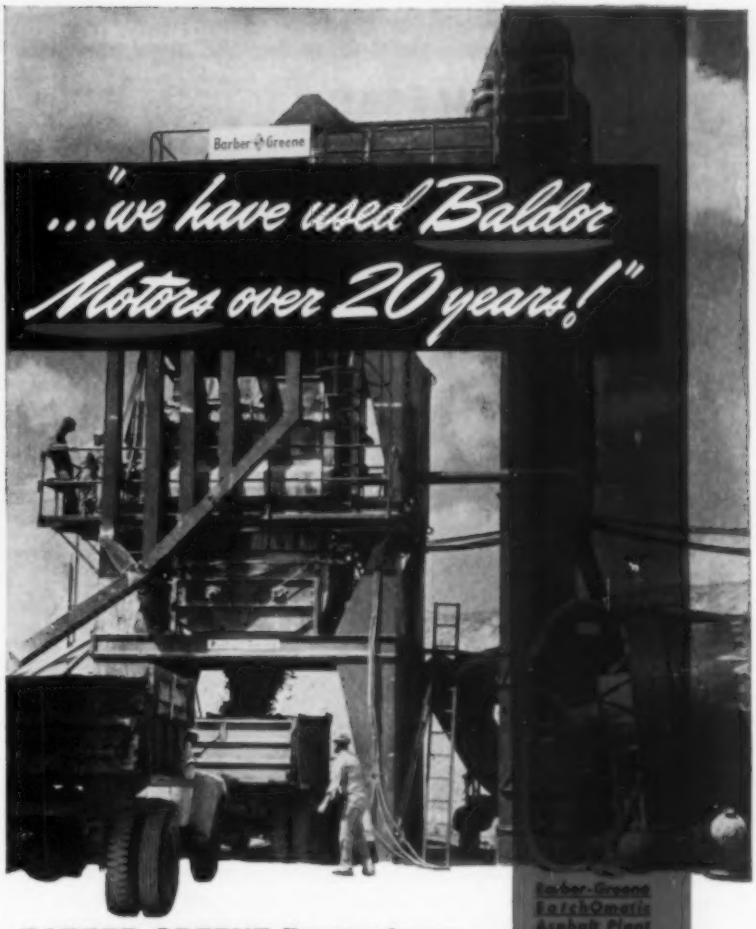
for hydraulic use is offered in sizes from ⅜ to ¾ in. dia with a stroke range of ½ to 6 in. Originally designed for metal toy industry, steel and aluminum unit is produced in a selection of anodized colors. **Mo-Bar Hydraulic Sales, Inc., Crystal Lake, Ill.**

Circle 18, Inside Back Cover

Transistorized digital systems . . .

consist of a digital voltmeter, control unit, ratiometer, ohmmeter, ac converter, master scanner and (available) printer units. Voltmeter features polarity symbols, decimal point and ac symbol. Bridge linearity is greater than 0.01% and bridge resistance is 50K ohm. Accuracy is said to be greater than 0.01%. Meter units have stepping

(Continued on page 102)



Barber-Greene Batch-Omatic Asphalt Plant

Up to 6 Baldor Streamcooled Motors are used to power these gigantic machines

BARBER-GREENE Depends on Baldor Streamcooled Motors to Power Its Asphalt Batch Plants & Belt Conveyors!

Despite the most torturous use, plus the constant hazard of dust and dirt, Baldor Streamcooled Motors keep famous Barber-Greene equipment operating at top efficiency, day after day.

This kind of superior performance has earned Baldor an enviable reputation among many outstanding heavy equipment manufacturers.

If you have a power problem that demands the utmost in motor performance, perhaps Baldor can help you, too!

Find out why you get *more* with Baldor —write for FREE color catalog!

BALDOR ELECTRIC COMPANY

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Over 400 Authorized Sales & Service Distributors in U. S. A.

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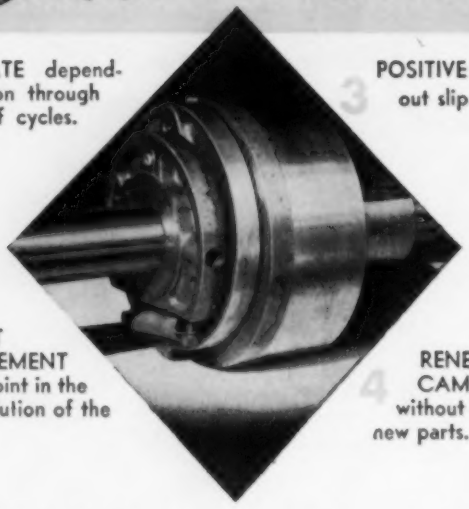
HILLIARD CLUTCHES FOR POWER CONTROL DESIGNS

HILLIARD

***Single Revolution* CLUTCH**

1 ACCURATE dependable action through millions of cycles.

3 POSITIVE motion without slip or lag.



2 INSTANT ENGAGEMENT at any point in the the revolution of the driver.

4 RENEWABLE CAM SURFACES without machining or new parts.

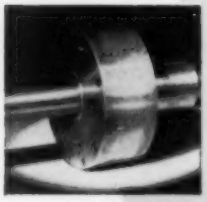
The Hilliard Single Revolution Clutch *is automation* because it provides precise accurate intermittent motion automatically. Control can be electrical or mechanical.

The use of Hilliard Single Revolution Clutches has improved the operation of tube straightening and cut-off machines—shears—conveyors—riveting and fastening units—case loaders—bottle unscramblers—weighing and packaging—indexing and feeding—marking—punching—textile and business machines—radar apparatus—proportionate pumps—and many other types of mechanisms.

WRITE TODAY FOR BULLETIN 239 WITH COMPLETE INFORMATION.

• OTHER HILLIARD CLUTCHES •

CONSIDER AUTOMATION - INVESTIGATE THESE PRODUCTS



OVER-RUNNING CLUTCHES for automatic instantaneous engagement and release on two speed drives, dual drives and ratchet or backstop action. Ask for Bulletin 231.

HILLIARD - TWIFLEX CENTRIFUGAL COUPLING for smooth, easy starting of any load automatically with overload protection and ability to accommodate shaft misalignment. Ask for Bulletin CE-3.

SLIP CLUTCHES for overload protection, or constant torque and to provide constant tension and permit speed variation on rewind stands. Ask for Bulletin 300.

THE HILLIARD CORPORATION

MANUFACTURING CLUTCHES FOR OVER 50 YEARS

101 W. FOURTH ST. ELMIRA, N. Y.

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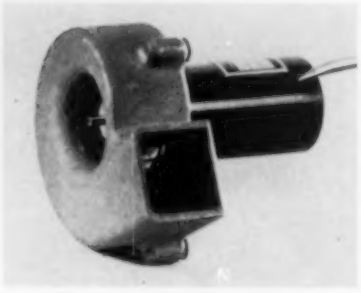
switches mounted on horizontal bars that swing up and out for easy access, and front panel locking knobs that allow each unit to slide in and out of the standard size chassis. All units are 17 x 3½ x 11⅜ in. deep. **Cubic Corp., San Diego, Calif.**

Circle 19, inside back cover



Miniature centrifugal blowers . . .

deliver up to 45 cfm free air and incorporate either a 1½ or 2-in. rotor. Can be furnished with rectangular or round outlet for attaching ductwork. Clockwise or counterclockwise scrolls are available. Motors are for 50 to 1000 cps with voltages up to 200 v ac, single or three-phase operation. Each unit weighs from 16 to 19 oz. **Globe Industries, Inc., 1784 Stanley Ave., Dayton 4, Ohio.**

Circle 20, inside back cover

Digital logging clock . . .

indicates and/or records time of day. A single-plane, in-line lamp bank assembly has individual time-reset pushbuttons for each decade so that a desired value in a particular column can be set without interaction between columns. Stepping switches provide electrical contact output. Several standard models, with either one or two sets of contacts wired to a quick disconnect plug for remote operation of electric equipment, are offered in 24 and 12-hr am-pm configurations. **Parabam, Inc., 110 Lomita St., El Segundo, Calif.**

Circle 21, inside back cover

Larger head diameters . . .

in socket head cap screws are said to permit load increases up to 134% more than before. Head dia has been increased in

(Continued on page 107)

Faster reference . . . Faster printmaking

with Recordak Precision Engineering Drawing System

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All types of drawings, negative and positive prints—old or new, clean or dirty—can be reproduced on Recordak 35mm microfilm. Ends need for costly, larger size films. And the next step—mounting each negative on its own Filmsort aperture card *provides an active drawing file that takes 95% less space.*

Free booklet explains new Recordak Engineering Drawing System in detail . . . tells how it can be tied into existing, mechanized filing and duplicating installations for even greater savings.

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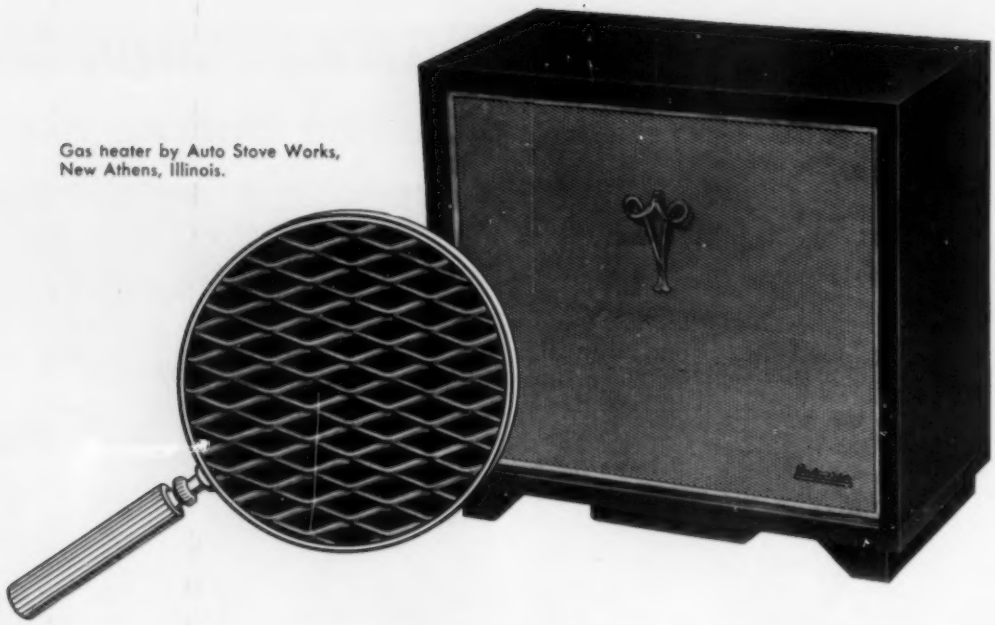


Gas heater by Auto Stove Works, New Athens, Illinois.

Functional beauty of Penmetal Minimesh highlights modern space heater

Handsome in appearance, the Autocrat space heater is styled to harmonize with contemporary interiors. The crowning touch: Penmetal Minimesh front panel in blending tone of antique gold.

But the Minimesh is more than distinctive looking. It is functional—permitting heat to circulate freely, and providing a strong, durable guard. What's more, it is surprisingly low in cost.

Minimesh is small-mesh expanded metal that is ideal for decorative purposes, guards or grilles. Like the larger meshes, it is sheet metal, slit and expanded to as much as five times its original width. Up to 80% lighter than solid sheet of the same area, the diamond truss pattern adds strength and rigidity

Re-examine the materials you use in your designs in the light of a growing trend to expanded metal. Complete data on Minimesh is available. Ask for folder 510-EM.

PENN METAL COMPANY, INC.

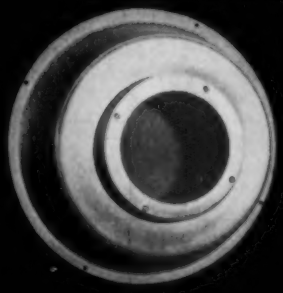
General Sales Office: 40 Central Street, Boston 9, Mass.
Plant: Parkersburg, W. Va.
District Sales Offices: Boston, New York, Philadelphia, Pittsburgh, Chicago, Detroit, St. Louis, Dallas, Little Rock, Seattle, San Francisco, Los Angeles, Parkersburg

Penmetal

a name to remember

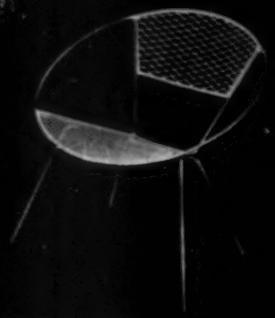
PM-167

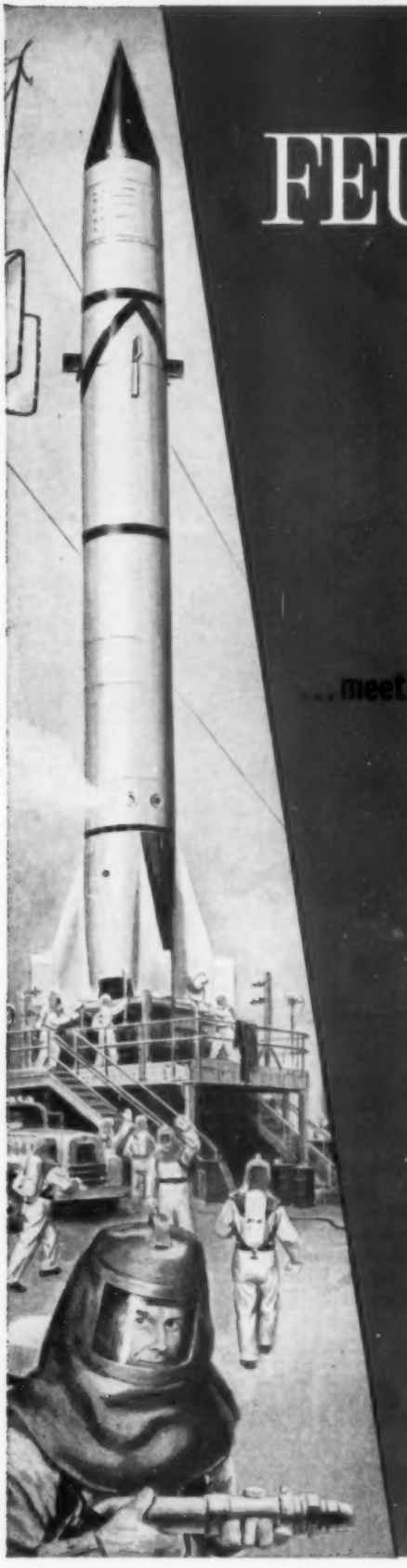
TWO OTHER APPLICATIONS FOR PENMETAL EXPANDED METAL



Hi-Fi speaker grille made by Lowell Manufacturing Co., St. Louis, Mo.

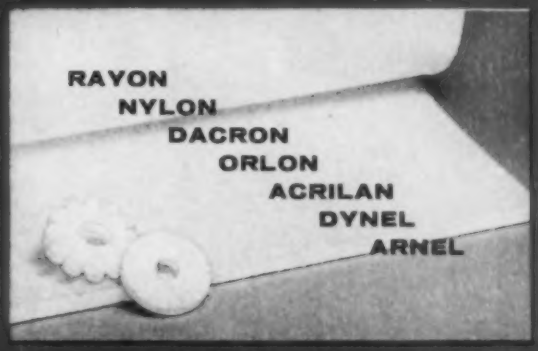
Metal chair, a product of Hoffman Company, York, Pa.





SYNTHETIC–FIBER

FEUTRON FELTS



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Exclusive Thermal and Chemical Properties Are Combined in These Newest of Engineering Materials

NOW – Conquer your most exacting design problems with this *completely new* class of materials!

Feutron Felts are mechanically interlocked, synthetic fiber, engineering materials . . . perfected after years of research by American Felt Company.

Durably fabricated from selected man-made fibers – Rayon, Nylon, Dacron,[1] Orlon,[2] Dynel,[3] Arnel,[4] Acrilan[5] – they provide *all* the valuable operating properties of these synthetics . . . high tensile strength; superior resistance to acids, alkali, solvents and other chemicals or gases; dimensional stability; three-dimensional physical properties *plus* the ability to operate at temperatures up to 400°F!

You'll find Feutron Felts are being used for wet and dry filtration, as high temperature oil seals, as reinforcements for plastics, as rugged gaskets, as lubrication wicks, as thermal and acoustical insulation and in hundreds of other vital applications.

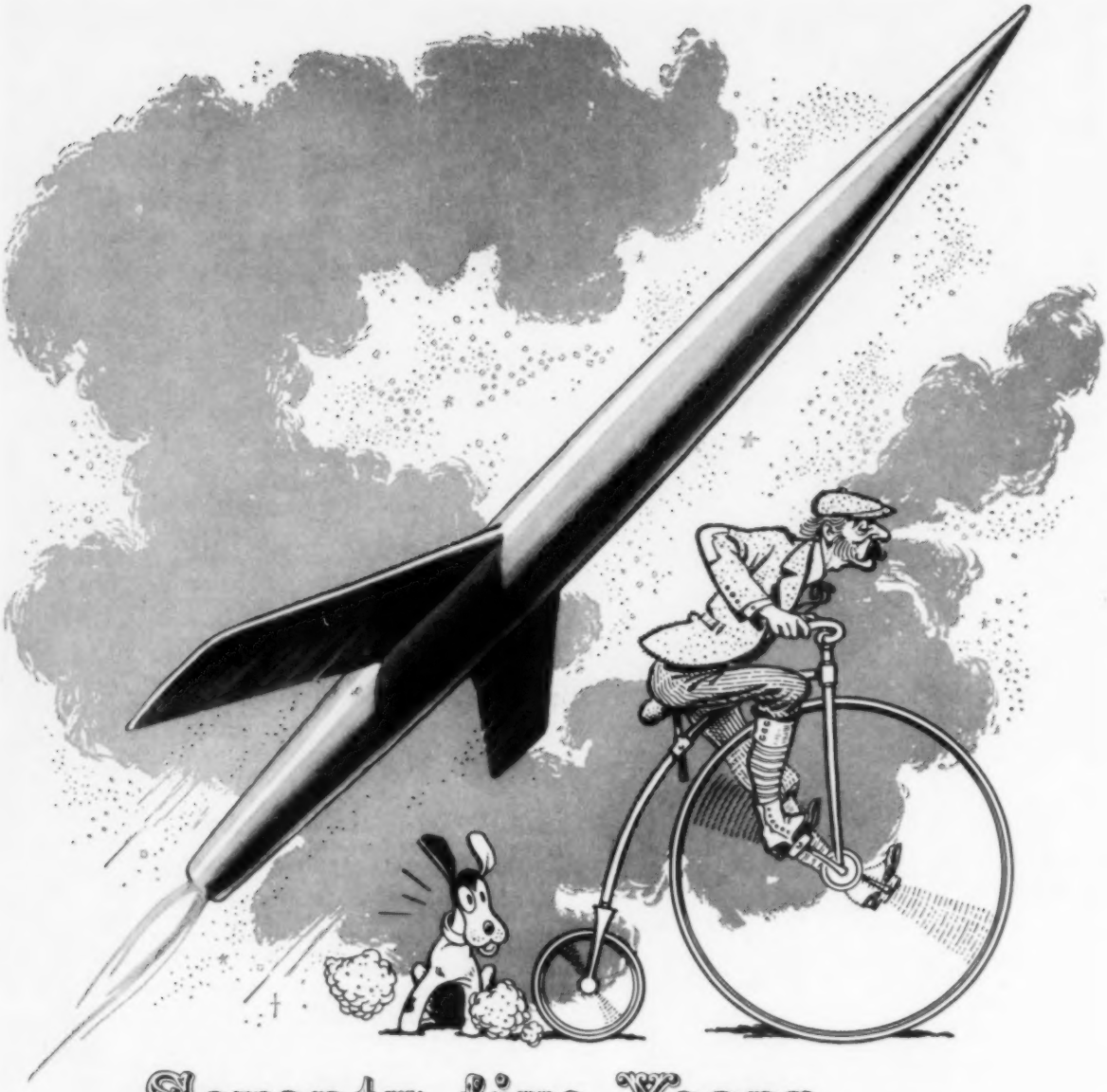
Where could you be using Feutron Felts to improve product performance? Get all the facts . . . write today, for Feutron Data Sheet, on company letterhead please.

Remember: American Felt Company has the most extensive and best equipped staff of product engineers in the Felt industry . . . ready to help you select the most efficient wool or synthetic fiber Felt for your application.

General Offices and Engineering and Research Laboratories
78 Glenville Road
Glenville, Conn.

American Felt Company
TRADE MARK

1. Du Pont polyester fiber trademark.
2. Du Pont acrylic fiber trademark.
3. Carbide & Carbon Chemicals Co. acrylic fiber trademark.
4. Celanese Corp. triacetate fiber trademark.
5. Chemstrand Corp. acrylic fiber trademark.



Seventy-five Years ◇◇◇

TEN MILES an hour was "speed" in 1883 when Wyman-Gordon started to make forgings for the high-wheel bicycle. Through the 75 intervening years forgings have made important contributions to the phenomenal advances in propulsion. Progress from the first "horseless carriages"...from the early "flying machines"...to the supersonic speeds of today ...would not have been possible without forgings produced by the most advanced techniques of the day.

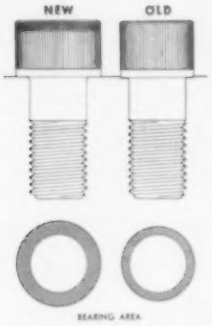
Wyman-Gordon is proud of its achievements in these fields and, as the largest producer of automotive and aircraft forgings, is prepared to accept the challenge of the future. Today, as for 75 years, there is no substitute for Wyman-Gordon quality and experience.

WYMAN-GORDON COMPANY

Established 1883

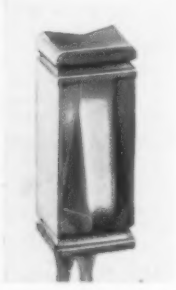
FORGINGS OF ALUMINUM • MAGNESIUM • STEEL • TITANIUM

WORCESTER 1, MASSACHUSETTS
HARVEY, ILLINOIS • DETROIT, MICHIGAN



the 1/8, 5/16, 3/8, 1/2, 3/4, 7/8 and 1-in. body dia sizes. Larger heads reduce bearing pressure by spreading load over a greater area. Heads were scaled up to hold bearing stress to 80% of axial tensile load on screw. Under given load, conventional socket screw indents bolted material, reducing holding power and lessening resistance to fatigue. Bigger socket permits installation torques about 10% higher than those recommended for standard units. **Standard Pressed Steel Co., Jenkintown, Penna.**

Circle 22, inside back cover



Waterproof hand switch . . .

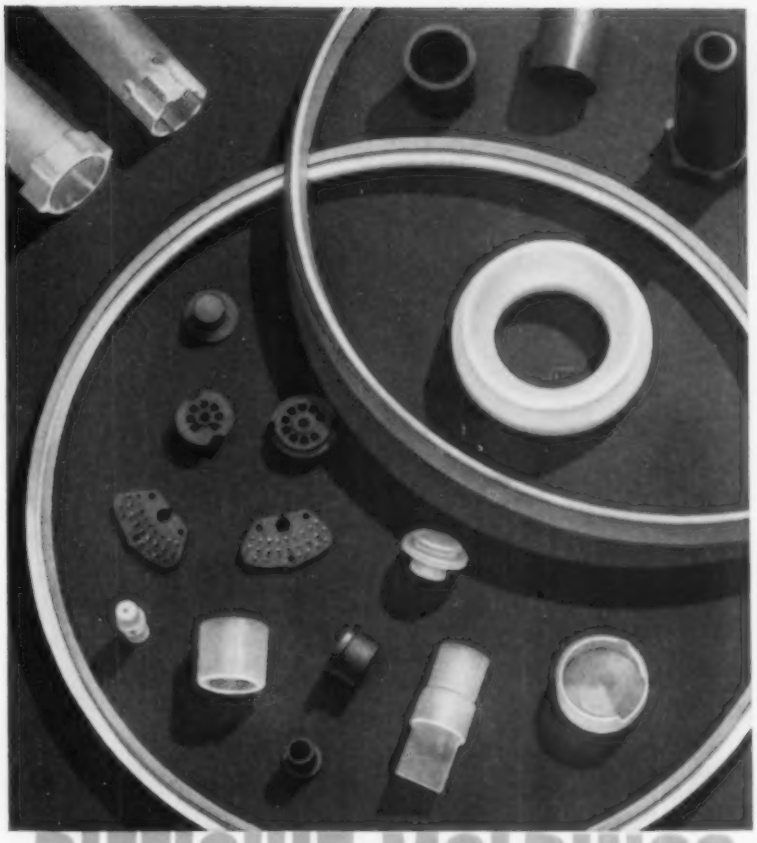
gives fingertip control for recycling by means of a lever actuator. Lever is enclosed in a silicone boot that protects mechanism. Switch can be made with normally open or normally closed contacts. Electrical rating is 15 amp resistive at 115 v ac. Operating life expectancy at peak current flow is 25,000 cycles min. A full-width, lengthwise V-groove for attaching to various diameters of supports is at back of switch. Small crosswise grooves on top and two sides of each end of casing are for mounting. **Control Products, Inc., 306 Sussex St., Harrison, N. J.**

Circle 23, inside back cover

Solid film lubricant . . .

uses a new metallic bonding principle that increases number of applications in which it can be used for lubrication of moving parts. Matrix-bonded lubricant contains molybdenum disulfide. Film is

(Continued on page 111)



DIFFICULT MOLDINGS
from TEFLON, KEL-F

United States Gasket specializes in difficult moldings involving precision tolerances, intricate shapes, delicate wall sections, inserts, molding around metallic structures, inside and outside threaded parts, etc.

They are equipped with unusual "know-how" gained as pioneers and leaders in fluorocarbon plastics fabrication, and the most modern specialized facilities and techniques for cold molding and sintering of TEFLON* T.F.E., as well as the injection molding of KEL-F† and the new thermoplastic TEFLON F.E.P.

Send us your difficult fluorocarbon molding problems for quotations. And call upon us, too, for your requirements of fluorocarbon and nylon sheets, discs, tape, rods, tubing, bars, cylinders, etc., from the world's largest and most complete stocks.

*du Pont Trademark
†M.M.&M. Trademark

For prompt service, contact one of The Garlock Packing Company's 30 sales offices and warehouses throughout the U.S. and Canada, or write

United States Gasket Company
Camden 1, New Jersey

United States Gasket
Plastics Division of GARLOCK

PROOF OF EXTRA SAFETY...

ONLY GREER ACCUMULATORS MEET ALL SAFETY CODES!

Qualify for any type hydraulic installation under all safety ordinances everywhere because . . . they're

BURST-PROOF!

Design engineers using hydraulic accumulators on machines and equipment in interstate commerce must be aware of stringent nation-wide safety regulations. For guaranteed acceptance everywhere, specify the Greer Accumulator — the only accumulator that meets all safety codes. More than 81,000 Greer Accumulators are now in use in every state of the union and in almost every industry. These exclusive built in safety features tell you why:

AIR VALVE Absolutely leak-proof for pressures up to 12,000 psi. Integrally molded one-piece valve stem prevents gas loss.

SHELL No seams. No welds. No joints. Made of single-piece homogenous chrome molybdenum steel. 18% elongation in two inches guarantees against metal fatigue. 5 to 1 safety margin above maximum working pressure of the accumulator.

MOUTH Designed to yield at 400% of maximum working pressure. This safety feature releases pressure if relief valve clogs or sticks, or if system is blocked.

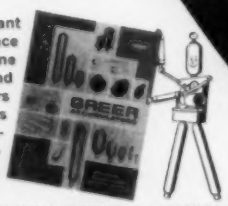
PLUG ASSEMBLY Accumulator cannot be disassembled until complete gas charge in bag has been released. Lack of this safety feature has caused serious accidents. Be sure to check this protection.

Greer Accumulators meet all J.I.C. and I.C.C. safety standards including the strict Penn. Boiler code, and conform with all municipal, state and insurance underwriters safety codes in accordance with ASME specifications on unfired pressure vessels.

Learn more about Greer Accumulators and how they can cut costs on your hydraulic equipment. Contact the franchised Greer distributor in Buffalo, Cleveland, Houston, Philadelphia and Pittsburgh. Inquiries invited from distributors in other areas.

WRITE OR PHONE FOR GREER BULLETIN PR-200

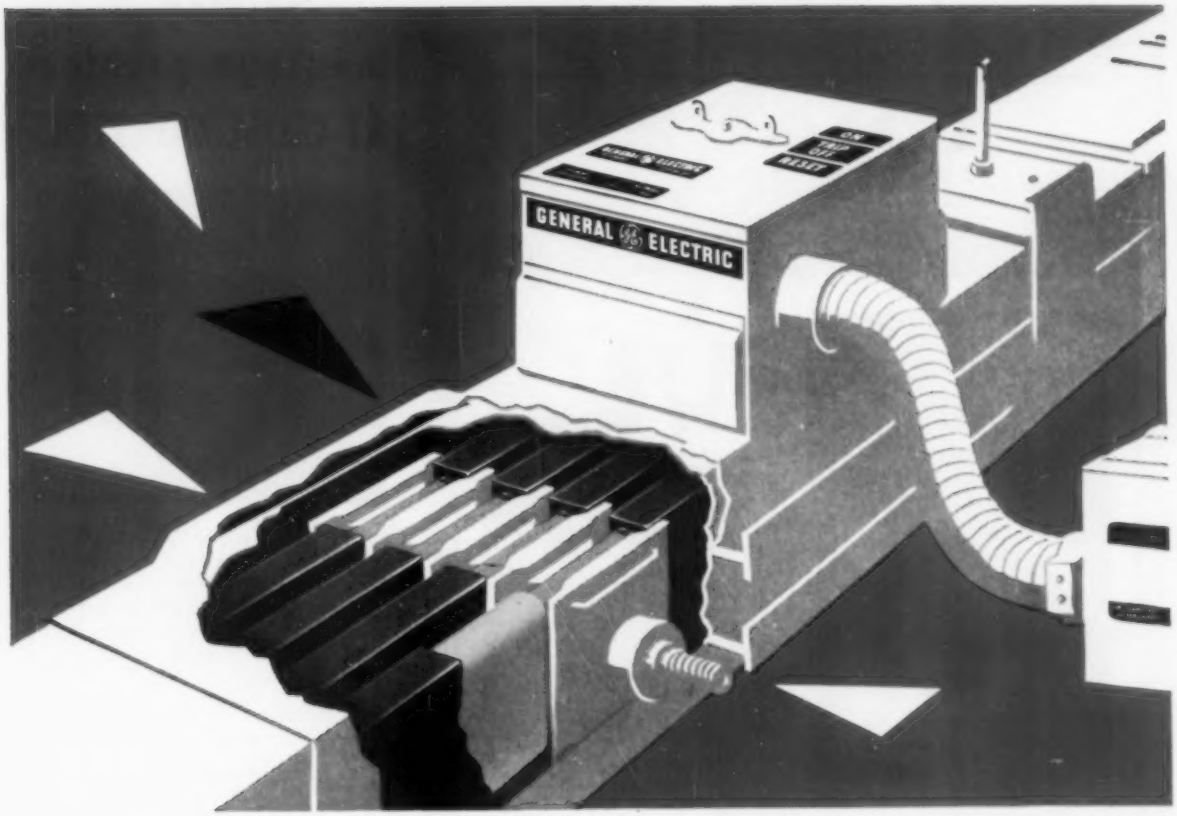
An important catalog reference on the complete line of Greer standard and special accumulators with circuit diagrams and applications. Also details on hydraulic components made by Greer such as valves, filters, actuators, etc.



U. S. PATENTS UNDER GLAER LICENSES

GREER HYDRAULICS INC. • INTERNATIONAL AIRPORT • JAMAICA 30, NEW YORK

Manufacturers of Precision Test Equipment and Hydraulic Components



When Enjay Butyl is used as continuous insulation of tubular aluminum conductors, traveling arcs are virtually eliminated, plug outlets are essentially dead-front.

ENJAY BUTYL

helps keep costs low in new Aluminum Busway!

Enjay Butyl is extruded over the full length of the conductors used in General Electric's new Type DE Busway, the first busway designed specifically for aluminum. This new busway incorporates all 22 features that engineers consider important in busway design, yet it is up to 30% smaller and 50% lighter than other busways of comparable rating.

Enjay Butyl rubber is ideal for use as continuous insulation of tubular conductors because of its inherent resistance to ozone and to heat aging. Add Butyl's excellent electrical properties, its vulcanizability and the fact that it is the *lowest cost* rubber on the market—and you'll understand why it was chosen above all other rubbers to do this job.

Every day manufacturers are discovering new ways to use economical Butyl. Find out how Enjay Butyl rubber can cut production costs for you. For further information and expert technical assistance, contact the Enjay Company.

ENJAY BUTYL

Enjay Butyl is the greatest rubber value in the world. It's the super-durable rubber with *outstanding* resistance to aging • abrasion • tear • chipping • cracking • ozone and corona • chemicals • gases • heat • cold • sunlight • moisture.

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Pioneer in Petrochemicals

ENJAY COMPANY, INC., 15 West 51st Street, New York 19, N. Y.

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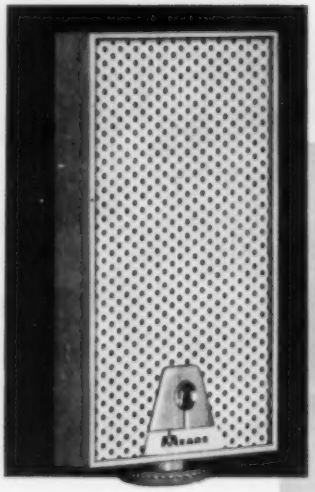
CHACE
THERMOSTATIC BIMETAL

Actuates Another Precision Product . . .



the MEARS

line voltage thermostat for electric heat

A Product of
Mears Electric Controls, Inc.
Swan Island, Portland 17, Oregon

"Sleek, slim and superbly engineered" is the Mears "decorator" room thermostat for all types of electric heating. And this is no idle boast, as the specifications indicate. It's flat and unobtrusive—but handsome when noticed—and it's engineered for accurate control of heating and cooling. Quick response is possible because this sensitive instrument is designed with full perimeter air space between wall and thermostat. The face panel is perforated to allow radiant heat to strike the sensing bimetal. Of course, the actuating element of Chace Thermostatic Bimetal assures dependability and sensitivity and the adaptable design make the Mears "decorator" one of the most acceptable electric heat wall controls available, either painted to match wall color or in its neutral "Desert Sand". Four models are offered: single and double line break, modulating and load transfer thermostats.

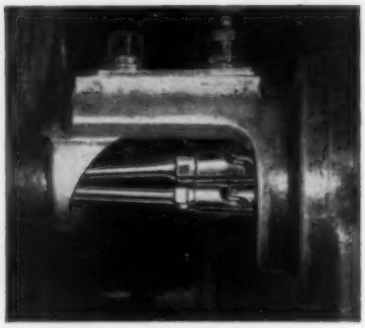
Chace is proud to be selected by manufacturers such as Mears to whom quality is a fetish. We try to earn such confidence by devoting our experience of over a third of a century exclusively to the development and processing of precision thermostatic bimetal. Chace quality standards, proved and protected by rigid inspection procedures, are the manufacturer's assurance that his product will provide a long and useful life without attention or service of any kind.

So remember Chace when you design for protection of valuable equipment or for temperature actuation or indication. Dependable Chace Thermostatic Bimetal is available in over 30 types, in strip, coil or completely fabricated and assembled elements to your design. Write today for new 1958 booklet, "Successful Applications of Chace Thermostatic Bimetal", containing many pages of design data.

IT BENDS WITH THE HEAT

W. M. CHACE CO.
Thermostatic Bimetal
1607 BEARD AVE., DETROIT 9, MICH.

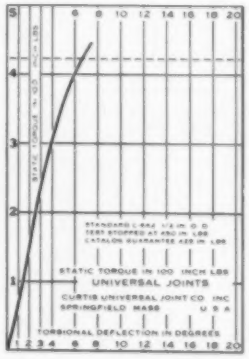
Solving a breakage problem AT CLOSE QUARTERS



The manufacturer of this button-drilling machine had a tough problem: the universal joints on these parallel shafts carried such a torque load there were frequent complaints of breakage . . . yet the close centers prohibited use of a larger joint.

THE SOLUTION was a Curtis Universal Joint of the same size.

Torque Curve ½" Curtis Universal Joint


STATIC TORQUE IN 100 INCH LBS
UNIVERSAL JOINTS
CURTIS UNIVERSAL JOINT CO. INC
SPRINGFIELD MASS U S A
TORSIONAL DEFLECTION IN DEGREES

This is only one of many problems solved by Curtis Joints — size for size the strongest universal joints designed for industry. Selected materials, precision engineering, and over 30 years' experience manufacturing universal joints make them that way.

14 SIZES ALWAYS IN STOCK —
⅜" to 4" OD (6" joints on special order)

Not sold through distributors. Write direct for free engineering data and price list.

TRADE MARK **CURTIS**
UNIVERSAL JOINT CO., INC.
11A Birnie Avenue, Springfield, Mass.
As near to you as your telephone

EXCLUSIVELY A MANUFACTURER OF UNIVERSAL JOINTS SINCE 1919

said to eliminate galling and seizing under extreme pressures and temperatures, and is inert to unusual atmospheres. It will also speed up parts assembly, prevent fretting corrosion and facilitate break-in lubrication of engine parts and other components. **Hohman Plating & Mfg. Co., 814 Vermont Ave., Dayton, Ohio.**

Circle 24, inside back cover

Nickel-silicon copper . . .

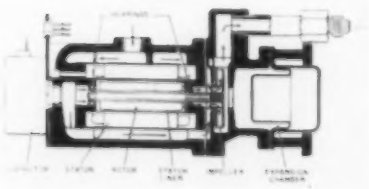
alloy combines high yield strength and high ultimate tensile strength at temperatures to 700 F. The alloy is age-hardenable and available in soft, cold forming and hard tempers. It will not age-harden at storage temperatures. Cold forming temper permits easy material flow for fabrication involving severe or complicated work. In hard temper it can be machined or given moderate cold working without further treatment. Electrical conductivity is said to be excellent. Alloy has uniform distribution of strength and hardness throughout, with identical properties for whole range of sizes. Available in a variety of cross-sections and dimensions in straight lengths of rod and bar and coils of round, rectangular and square rolled and drawn wire. **Chase Brass & Copper Co., Waterbury, Conn.**

Circle 25, inside back cover

Duplex pressure switch . . .

senses pressures at various parts of a hydraulic system through two pressure ports that accommodate different pressure settings. Adapter plate, with single pressure port, cross-drilled to serve both switches, is available. Springs for pressure adjustments from 50 to 5000 lb are available. Two separate SPDT switching elements, rated 5 amp, are provided. Switches have standard wiring, normally closed. **Oil-Dyne, Inc., W. Marquette Rd., Chicago 36.**

Circle 26, inside back cover



Pump and motor . . .

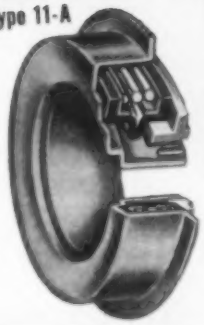
are sealed within same case, preventing shaft leakage and minimizing size and weight. Cooling and lubrication are affected by channeling the fluid being pumped through and around metal stator case to immerse rotor and stator. Some

(Continued on page 112)

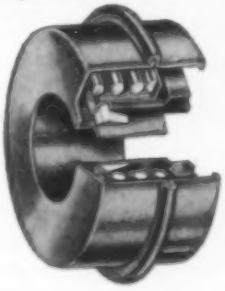
3 JOHN CRANE "Pressed-In" SEALS
for economy, quick installation and life-long performance in all types of service

TYPE 11-A
Synthetic Rubber Bellows • Small shafts to ¾ in.
Services: hot or cold water, oil, gasoline, kerosene and other liquids non-injurious to synthetic rubber.
Pressures: up to 50 psi.
Temperatures: –65°F. to +220°F. Special construction to +300°F.
Construction Data: Packaged unit. Retainer does not contact shaft, permitting operation at a high rpm. One size can be used for several shaft sizes. Bellows encloses spring and metal parts to prevent contact with medium being sealed.

TYPE 6-A
Synthetic Rubber Bellows • Interchangeable with Type 11-A
Services: hot or cold water, oil, gasoline, soapy and other liquids non-injurious to synthetic rubber.
Pressures: up to 75 psi.
Temperatures: –65°F. to +220°F. Special construction to +300°F.
Construction Data: Similar to Type 11-A. Does not contact shaft, permitting operation at high rpm. One size can be used for several shaft sizes. Spring and metal parts available in stainless steel or bronze.

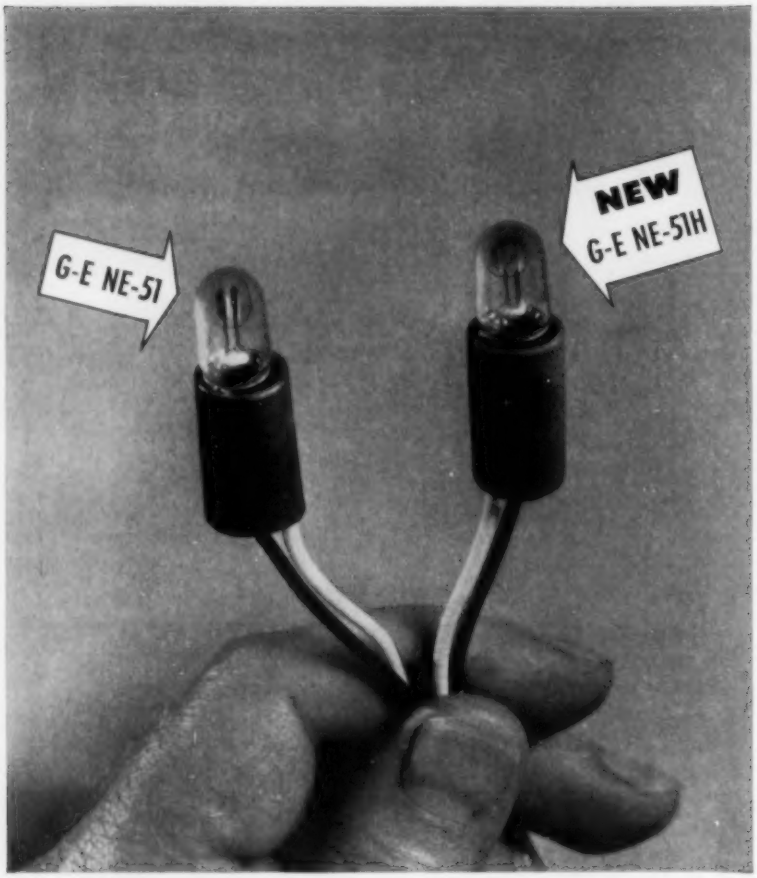


TYPE 9-A
Sealing Members Made of Teflon* • Engineered for the particular application
Services: all chemicals, solvents, oils, corrosives and gases, hot or cold.
Pressures: to 150 psi. Balanced construction to 750 psi.
Temperatures: –120°F. to +500°F.
Construction Data: Packaged unit. Furnished in metallurgical specification best suited to the application. Chemically-inert Teflon wedge ring closely fits inner sleeve of retainer and is machine-mated to carbon sealing washer.



Contact "John Crane" for the particular seal best suited to your application. Request bulletin giving full information on "John Crane's" complete line of mechanical seals.
Crane Packing Co., 6445 Oakton St., Morton Grove, Ill., (Chicago Suburb).
*In Canada: Crane Packing Co., Ltd., Hamilton, Ont.
*DuPont trademark

JOHN CRANE CRANE PACKING COMPANY 38 YEARS INDUSTRIAL PROGRESS



New G-E NE-51H glow lamp gives 20 times more light!

. . . without changing bulb size or shape!

Do your customers complain that indicator lamps seem to fade out when general lighting goes on? Here's a tiny but powerful glow lamp that's built to make indicators more readable—even in today's better lighted plants and homes.

The new G-E NE-51H gives 20 times more light than the familiar NE-51 when operated with the recommended resistors. It has the same bayonet base, same rugged construction that stands up under shock and vibration—and it uses approximately ¼ of a watt! Rated at more than 5,000 hours, it's ideal for machine tools, electrical controls and household appliances—plus hundreds of other applications where a brighter indicator is called for. There are considerable advantages in size and space over larger lamps of equal brightness—and they fit standard holders —AC only.

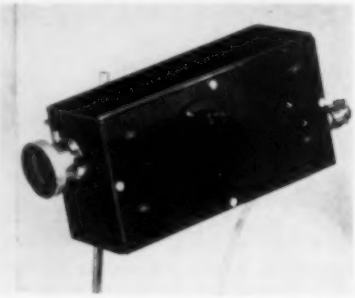
If you'd like more information on this versatile new G-E Glow Lamp, and how it can solve your indicator problems, write: General Electric Co., Miniature Lamp Dept. PE-58, Nela Park, Cleveland 12, Ohio.

Progress Is Our Most Important Product

GENERAL ELECTRIC

fluid enters rotor chamber from rear and passes around bearings and stainless steel canned rotor, providing cooling and circulation. Pumps operate most efficiently at −60 to 165 F. **Pacific Scientific Co., 6280 Chalet Dr., Bell Gardens, Calif.**

Circle 27, inside back cover



Measures temperatures . . .

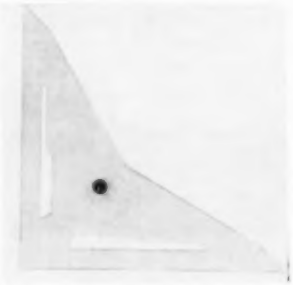
of any solid, liquid or luminous flame in the 1500 to 4000 F range without requiring emissivity corrections. Response speed is said to be a fraction of a second and accuracy is within 20 F. Instrument permits use of automatic controls and reading may be translated to control processing. A sensing head detects radiation and a control unit interprets data. **Shaw Instrument Corp., 49 Verona Rd., Pittsburgh 21.**

Circle 28, inside back cover

Hand sighting level . . .

provides a level line of sight that is factory calibrated to be accurate to within ¼ of 1°. When bubble, reticle and object coincide, they are at exact eye level. Differences in elevation between two points may be measured. $2.50 each. **Edmund Scientific Co., Barrington, N. J.**

Circle 29, inside back cover



Triple-angle triangle . . .

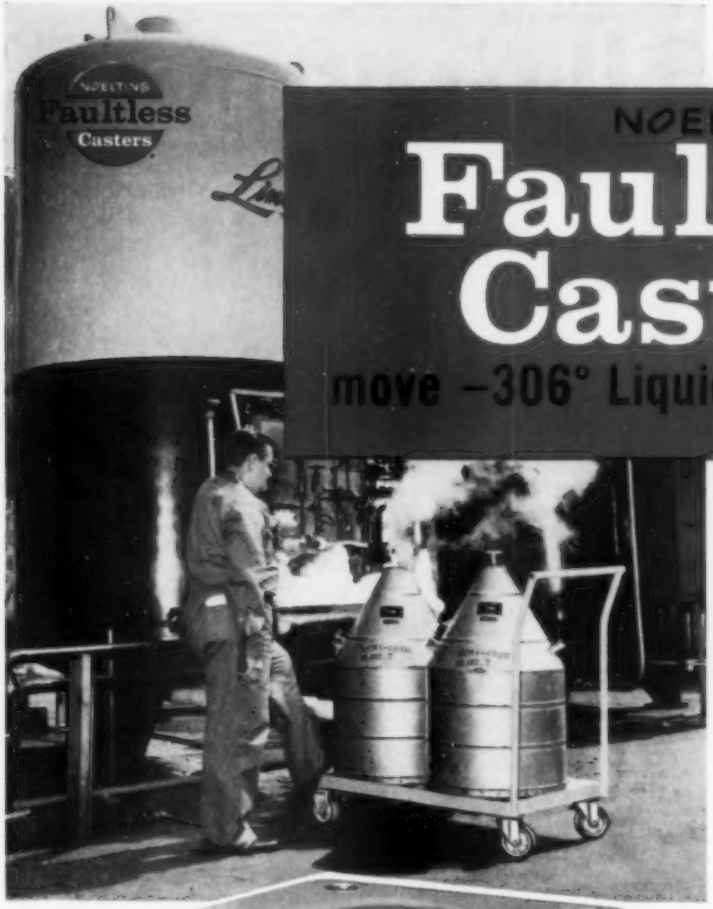
combines functions of 45°/90° and 30°/60° angles and built-in slot guides for 1/8, 1/4, 3/16 and 3/8-in. lettering. Transparent acrylic plexiglass triangle has lifting knob, 8-in. size, $2.75 each; 10-in., $3. **Alvin & Co., Windsor, Conn.**

Circle 30, inside back cover

NOELTING

Faultless Casters

move –306° Liquid Nitrogen Safely!



General Electric Semi-Conductor Plant, Buffalo, selected Series 1100 and 1700 Casters for the extremely critical job of moving –306° liquid nitrogen *in and out* of doors. Vacuum containers holding liquid gas remain on Faultless Castered trucks continuously for swift, sure delivery to the exact spot when needed. Because of the extremely low temperature of the gas, safety is important. Contact with the skin would cause an extremely severe burn.

Easy rolling, easy swiveling Faultless Casters assure shock-free movement —dangerous manual handling is avoided. Another way Faultless Casters increase materials handling efficiency for men in industry.

CUT YOUR HANDLING COSTS, MOVE LOADS QUICKER, SAFER

Series 1100 Double Ball Bearing Swivel Faultless Casters have two large-diameter hardened raceways and two full rows of hardened, ground ball bearings for maximum swiveling ease. The top and lower ball retainers, and horn are formed of heavy gauge steel.

Renewable Rubber Tired Wheels operate quietly and efficiently INDOORS OR OUT.

Faultless handles the tough jobs!

Series 1700 Rigid Plate Casters feature an exceptionally strong horn construction and are available with wheel types and sizes, load ratings and overall heights to match Companion Series 1100 Swivel Plate Casters.

Ask your Distributor!

Your nearby Faultless Industrial Distributor maintains a substantial inventory of Faultless Casters for immediate delivery. He and one of the strategically located Faultless Sales Engineers are available to work with you in every handling problem in your plant. Both are listed in the phone book Yellow Pages, under "Casters," beneath the Faultless heading.

Write for FREE Condensed 20 page Caster Catalog.

Faultless Caster Corporation
Evansville 7, Indiana

Send copy of condensed 20 page Caster Catalog, 157-G

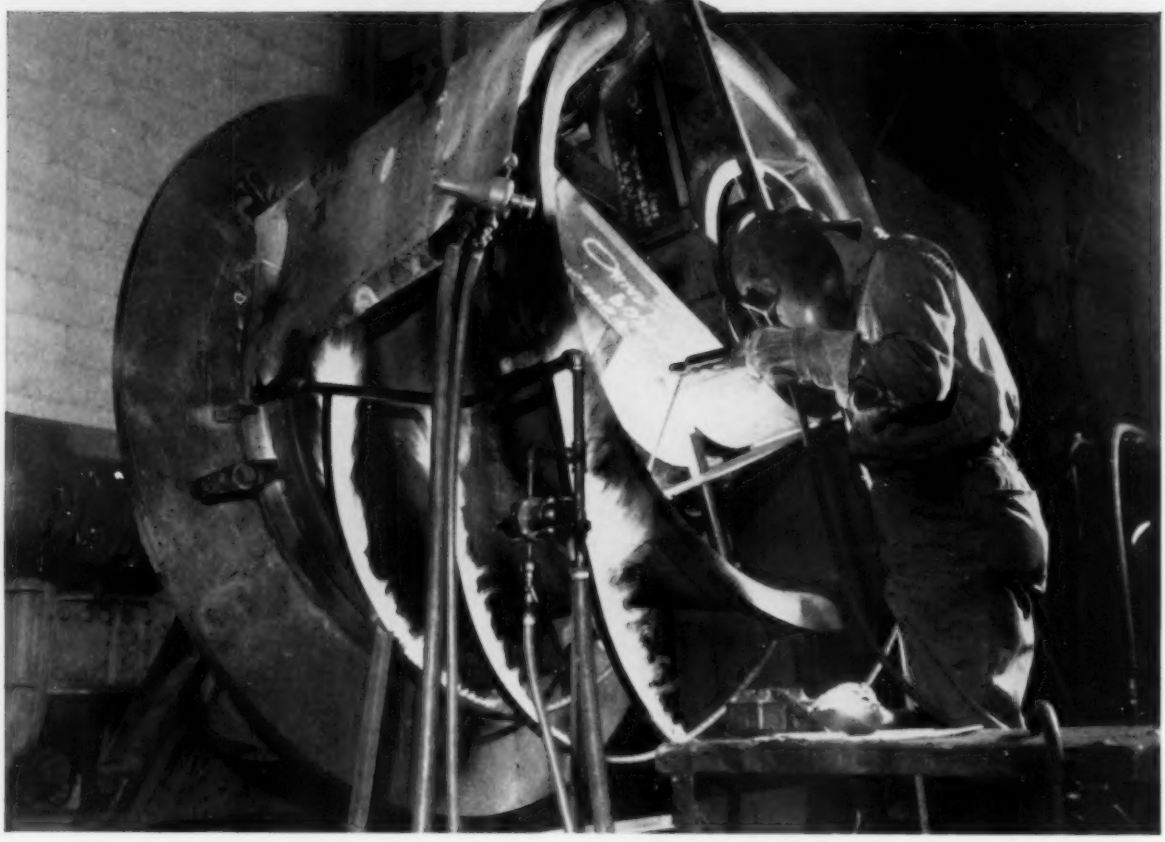
Name _____

Firm _____

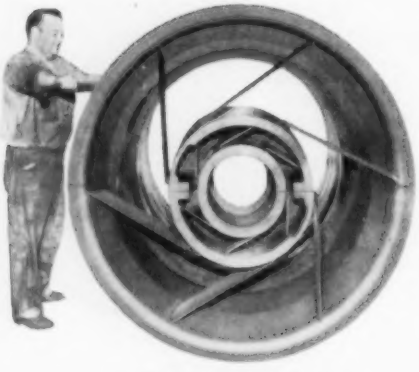
Address _____

City _____ State _____

STEEL-WELD FABRICATION . . .



Industrial GAS TURBINE Housings!



MACHINED WELDMENT

The gas turbine housing illustrated here is one of many produced and machined by the Mahon Company. Steel-Weld Fabrication of special alloy steel components for use in precision manufacture of gas turbines requires craftsmanship and control know-how.

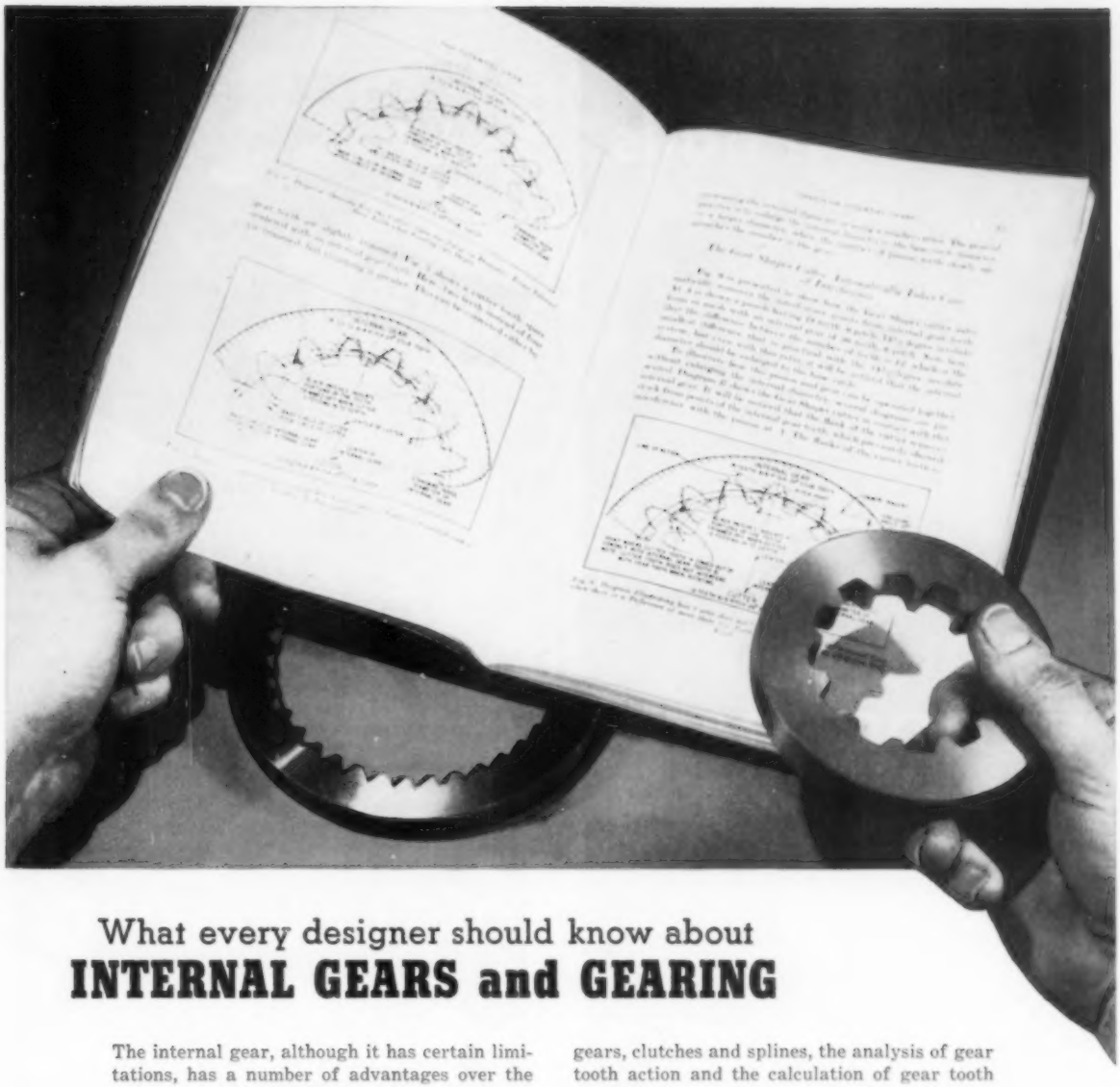
When you consider the use of welded steel components in the design of processing machinery, machine tools or other types of heavy mechanical equipment, you, too, will want to discuss your requirements with Mahon engineers; because, in the Mahon organization you will find a unique source for weldments or welded steel in any form . . . a fully responsible source with a long and enviable performance record, and unusual facilities for design engineering, fabricating, machining and assembling.

See Sweet's Product Design File for information, or have a Mahon sales engineer call at your convenience.

THE R. C. MAHON COMPANY • Detroit 34, Michigan

SALES-ENGINEERING OFFICES in DETROIT, NEW YORK and CHICAGO

MAHON



What every designer should know about
INTERNAL GEARS and GEARING

The internal gear, although it has certain limitations, has a number of advantages over the external gear, especially from the standpoint of compactness of design and more efficient tooth action. Most of the so-called limitations can be readily overcome by a proper understanding of the conditions to be met.

These advantages and limitations are explained in "The Internal Gear", a complete treatise on Internal Gear Design. This booklet contains information on the design and cutting of internal gears, clutches and splines, the analysis of gear tooth action and the calculation of gear tooth strength. Just write to any Fellows office for your copy.

Internal gears, as well as an almost unlimited variety of other internal contours, can be produced at low cost on Fellows Gear Shapers. In many cases the same Gear Shaper cutter can be used to cut both the internal gear and its mating pinion. Production is as simple as the production of external gears.

THE FELLOWS GEAR SHAPER COMPANY
78 River Street, Springfield, Vermont
Branch Offices:
1048 North Woodward Ave., Royal Oak, Mich.
150 West Pleasant Ave., Maywood, N. J.
5835 West North Avenue, Chicago 39
6214 West Manchester Ave., Los Angeles 45

THE PRECISION LINE Fellows *Gear Production Equipment*

look ahead with **Hartford**

Precision Balls

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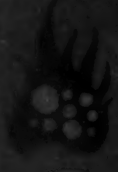

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CATALOGS and BULLETINS

To obtain copies of literature described below, circle corresponding number on postcard inside back cover.

IMPACT EXTRUSION—Booklet, 28 pp. Describes process, tooling required, applications, design considerations. Charts and tables note mechanical and physical properties and compare various weights and strengths of various alloys. Pheoll Mfg. Co., East U. S. 12, Michigan City, Ind.
Circle 31, inside back cover

SAFETY RELIEF VALVES—Catalog FE-118, 44 pp. Information on selection and sizing of nozzle safety relief valves applicable to process piping. A data section contains sizing factors and formulas; nozzle capacity for air, water, gas and steam; also dimension and weight tables. Farris Engineering Corp., 705 Commercial Ave., Palisades Park, N. J.
Circle 32, inside back cover

COLD FINISHED BAR PRODUCTS—Brochure, 28 pp. Offers tips and technical data on carbon steels, free machining steel, stress relief annealed steels, leaded steels, and alloy and stainless steels. Also, information on carbon corrections, special sections, turned ground and polished bars and furnace treatment. Republic Steel Corp., Massillon, Ohio.
Circle 33, inside back cover

SOCKET HEAD SET AND CAP SCREWS—Net price list SS106, 24 pp. Prices are given for bulk and package quantities of socket set screws, stripper bolts, dowel pins, socket head cap screws and pipe plugs. Abbott Screw & Mfg. Co., 1728 W. Walnut St., Chicago.
Circle 34, inside back cover

MINIATURE AND SUBMINIATURE RELAYS—Catalog, 16 pp. Data sheets contain specifications, adjustment schedules, dimensional and circuit diagrams. A special section includes data and charts for computing characteristics of relays under varying conditions. Electronics Div., Iron Fireman Mfg. Co., 2838 W. E. 9th Ave., Portland, Ore.
Circle 35, inside back cover

SEALING ALLOYS—Brochure, 4 pp. Properties and characteristics of glass-to-metal hermetic sealing alloys. Includes curve of thermal expansion. Wilbur B. Driver Co., 1875 McCarter Hwy., Newwark 4, N. J.
Circle 36, inside back cover

OBSERVATION WINDOWS—Bulletin 8-E, 4 pp. Specs and parts numbers for glass and plastic window models. Discusses features, applications, installation, pressure and temperature limits. Bijur Lubricating Corp., Rochelle Park, N. J.
Circle 37, inside back cover

MINIATURE BALL BEARINGS—Catalog supplement M1, 6 pp. Dimensions, tolerances, torque values, static and dynamic capacities and limiting speeds are given on miniature and instrument sizes, ⅜-in. OD and smaller. Barden Corp., 63 E. Franklin St., Danbury, Conn.
Circle 38, inside back cover

CARBON AND GRAPHITE BRUSHES—Bulletin, 12 pp. Describes and illustrates line of brushes for all types of rotating electrical machinery. Discusses selection, brush materials, design and split brushes. One table summarizes brush grades by group, grade designation and key characteristics. Speer Carbon Div., Speer Carbon Co., St. Marys, Penna.
Circle 39, inside back cover

PLASTIC KNOBS—Catalog, 8 pp. Contains diagrams, dimensions and specs of a representative selection of standard knobs. Waterbury Co's., Inc., 555 Washington St., Waterbury 20, Conn.
Circle 40, inside back cover

MEDIUM PRESSURE HOSE AND FITTINGS—Catalog 4420, 8 pp. Assemblies are cataloged and make-up instructions included. Shows reusable over-the-cover type fittings. Includes photos, diagrams, specs. Parker Fittings & Hose Div., Parker-Hannifin Corp., 17325 Euclid Ave., Cleveland 12.
Circle 41, inside back cover

SUBMINIATURE TEFLON TERMINALS—Catalog 2759, 8 pp. Dimensions and performance data on over 200 types of terminals. Electrical ratings are given in condensed form. Trinseel, Inc., Div. Tri-Point Plastics, Inc., 177 I.U. Willets Rd., Albertson, N. Y.
Circle 42, inside back cover

INDUSTRIAL PRESSURE GAGES—Catalog 305, 16 pp. Describes construction, specifications, dial graduations, and applications of general-purpose gages; altitude, refrigeration, ammonia, hydraulic,
(Continued on page 119)

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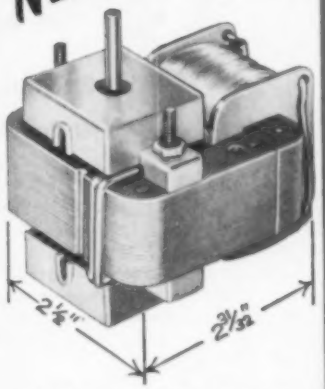

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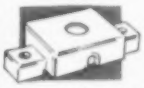

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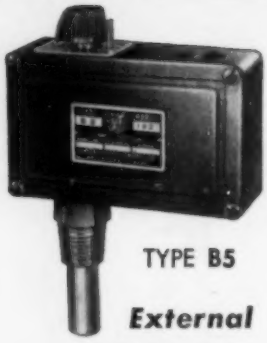

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duplex, solid front high pressure, vacuum and low-pressure diaphragm, pivoted movement differential, and indicating gages. Also pressure switches. United States Gauge, Div. American Machine and Metals, Inc., Sellersville, Penna.

Circle 43, inside back cover

MOTOR SELECTION—Guidebook, 12 pp. Information on typical driven equipment, character of loads, starting and running torques have been matched to motor designs, motor types and descriptions, starting currents, speed and horsepower ranges and available enclosures. Gives details on line of polyphase, single-phase and dc motors, 1/20 to 400 hp. Century Electric Co., 18th and Pine Sts., St. Louis 3.

Circle 44, inside cover cover

SUBMINIATURE SWITCHES—Bulletin, 4 pp. Covers standard line and variety of actuators. Photos, detailed drawings, descriptions, operating characteristics and electrical ratings are given. Unimax Switch Div., W. L. Maxson Corp., Ives Road, Wallingford, Conn.

Circle 45, inside back cover

COUPLINGS—Catalog C-210-A, 12 pp. Describes and illustrates coupling line, including new jaw-type couplings. Gives specs, ratings, list prices, dimensional drawings. Browning Mfg. Co., Maysville, Ky.

Circle 46, inside back cover

METER MOUNTINGS—Bulletin 601, 4 pp. Information on design, advantages and performance of bonded rubber mountings that protect sensitive instruments against shock and vibration. Specs include cross-reference table listing various meter manufacturers' models. Lord Mfg. Co., 1635 W. 12 St., Erie, Penna.

Circle 47, inside back cover

HYDRAULIC PUMPS, MOTORS—Technical bulletin, 2 pp. Describes pump and motor characteristics of Model A unit. With dimensional drawings, mounting information and performance curves. Berry Hydraulics, Div. Oliver Tyrone Corp., Pittsburgh 22.

Circle 48, inside back cover

LIGHTED PUSHBUTTON SWITCHES—Data sheet 133, 8 pp. Gives characteristics, electrical ratings, general description of 23 listings. Dimensional drawings of each switch are included. Micro Switch, Freeport, Ill.

Circle 49, inside back cover

SPONGE IRON POWDER—Brochure 112, 8 pp. Covers typical chemical analysis, some of the important basic and

(Continued on page 121)

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	1/4	7700	7360	14720
	5/16	11500	11500	22960
	3/8	17600	16580	33160
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This exceptionally small, precise sensing device assures ultra-precise limit switching, machine and edge control; actuates controls in production or inspection lines.

FEATURES:

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green properties, and presents graphically results of tests on plain iron mixes, iron-carbon mix, iron-copper mixes and iron-copper-carbon mixes. Hoeganaes Sponge Iron Corp., Riverton, N. J.

Circle 50, inside back cover

LOW-TEMPERATURE MELTING ALLOYS—Booklet J4, 8 pp. Illustrates and lists 63 applications of alloys in metalworking field. Also included are brief descriptions of various alloys and physical properties. Cerro de Pasco Sales Corp., 300 Park Ave., New York 22.

Circle 51, inside back cover

SPEED CONTROL VALVE—Bulletin 275, 2 pp. Describes valves which are used to control piston speeds of hydraulic cylinders and other hydraulically powered devices. Gives specs, installation data and dimensions. Hanna Engineering Works, 1765 Elston Ave., Chicago 22.

Circle 52, inside back cover

DRY FLUID DRIVES—Bulletin A665, 2 pp. Specs and dimensions of fhp drives and couplings, with prices. Also selection tables for determining size. Dodge Mfg. Corp., Mishawaka, Ind.

Circle 53, inside back cover

PHOSPHATE COATING FOR STEEL—Brochure, 4 pp. Describes various phosphate coatings on steel for bonding paint and protecting metal from underfilm corrosion. American Chemical Paint Co., Ambler, Penna.

Circle 54, inside back cover

MOTOR PROTECTORS—Bulletin PR-1243, 4 pp. Questions and answers about built-in three-phase motor protectors. Metals & Controls Corp., Spencer Thermostat Div., Attleboro, Mass.

Circle 55, inside back cover

LOW-COMPRESSION BUTYL COMPOUND—Engineering bulletin, 4 pp. General characteristics, laboratory evaluation, and performance data on new rubber compound. Precision Rubber Products Corp., Oakridge Dr., Dayton 7, Ohio.

Circle 56, inside back cover

REPRODUCTION MATERIALS—Booklet, 12 pp. Outlines ways that drafting room reproduction materials can provide shortcuts and savings. Graphic Reproduction Div., Eastman Kodak Co., Rochester, N. Y.

Circle 57, inside back cover

SPE PROSPECTUS—Brochure, 16 pp. Summarizes activities and benefits of society. Includes application form. Society of Plastics Engineers, Inc., 34 E. Putnam Ave., Greenwich, Conn.

Circle 58, inside back cover

FOOTE BROS. **Motorized Drives**

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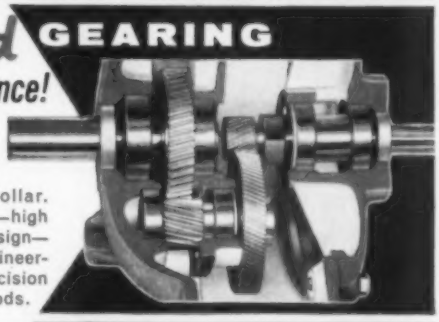

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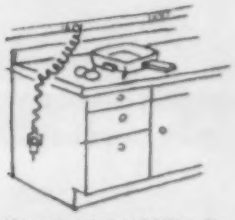

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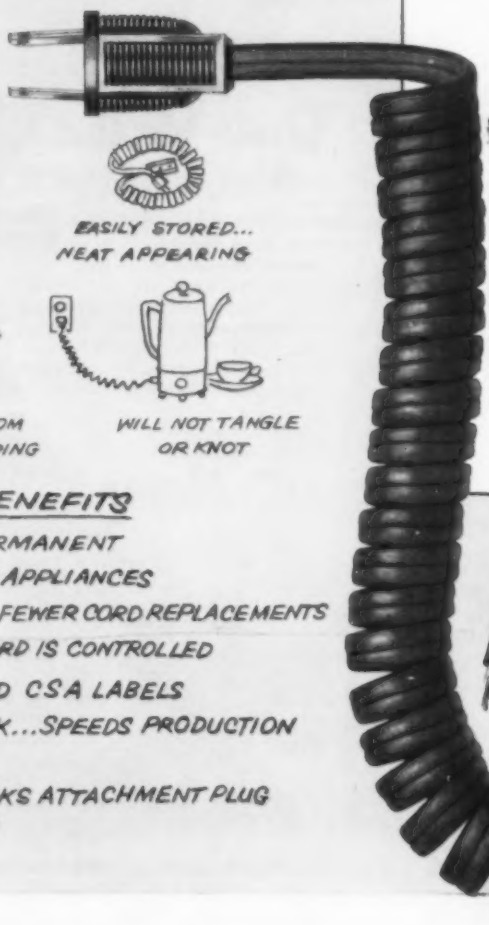

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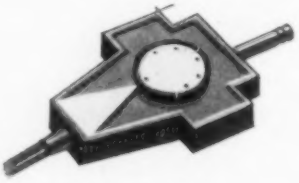

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DESIGN ABSTRACTS

Belt and Rope Drives

Basic principles and properties are outlined. Effects of initial tension, speed, coefficient of friction on power transmitted are discussed. Creep and catenary effects are illustrated numerically and running losses caused by bending and windage estimated.

Abstracted from "Design of Belt and Rope Drives," by G. H. Ryder, Mechanical World, April 1958, 31 King St. W., Manchester 3, England.

Unreliability of Electronic Equipment

Electronic equipment is shown to be far less reliable than structures and machinery. Primary cause is inadequacy of reliability concepts traditionally employed in electronics, particularly when compared to common practice in other branches of engineering design.

Abstracted from "Unreliability of Electronics—Cause an Cure," by Robert Lusser, Redstone Arsenal; 2nd Annual Meeting, Institute of Environmental Engineers, April 17-18, 9 Spring St., Princeton, N. J.

User-computer Communications

Bridging the Gap

Techniques and systems for automatic data coding are reviewed, as well as interpreting, assembly, compiling systems, and pseudo-codes and pseudo-languages. Future developments and probable associated requirements are discussed.

Abstracted from "Bridging the Gap Between User and Computer," G. M. Hopper, Sperry-Rand Corp., presented at April 13-18 meeting of Div. Industrial and Engineering Chemistry, American Chemical Society, 1155-16th St., N.W., Washington 6.

Human Error Frequency

Computers probably make less than one mistake in every 10^{20} digits transferred. Human error frequency is probably of the order of one mistake in every 200 digits. Means of enabling humans to improve this situation are discussed, in the following areas: need for investigating influences of perception, recognition, generation of native language concept; development of common-language concepts and symbolism (perhaps involving published catalogs); recognition of natural digit span and span of immediate memory in arranging number and letter sequences; aids to visual and other forms of perception; minimizing human invention and links in computer-communications systems; reserving for humans unusual judgment, moral and philosophical problems.

Abstracted from "Entering the Machine Domain," by S. L. Seaton, U. S. Army; Electrical Engineering, April 1958, 33 W. 39th St., New York 18.

Engineering Problems 6200 Miles Up

Some of the natural environmental conditions encountered by high-altitude vehicles, and which decisely affect their design and operation, are described in three main categories: atmospheric solids; atmospheric gases; fields, radiant energy and particles.

Abstracted from "A Synopsis of Natural Environments to Heights of 1000 Km," by A. P. Harris, and E. W. Parrott, Canadian Dept. of National Defence; 2nd Annual Meeting, Institute of Environmental Engineers, April 17-18, 9 Spring St., Princeton, N.J.

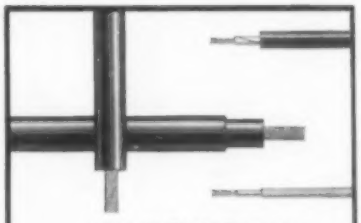
Wear of Metals

Significance of such wear factors as speed and load, geometry, lubricant, surface roughness, oxide films, abrasive matter, corrosive environment, metallurgical structure of subsurface regions are discussed. Pitting, scuffing, fretting are among the forms of wear investigated. It is concluded that metallurgical structure has a major effect on wear resistance.

Abstracted from "Wear of Metals," by F. T. Barwell, Head of Lubrication and Wear Div., Mechanical Engineering Research Laboratory, E. Kilbride, Glasgow, Scotland.

"Get lost, kid! That's just it—I am!"

They can be *your* design assistants on other Essex Engineered Products.



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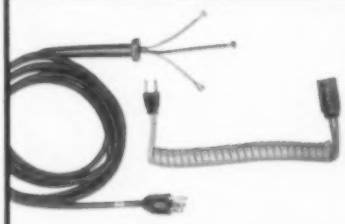
These "power full" lead, appliance, electronic, Sil-X 200°C and the Mil-W-76-A and Mil-W-16878 govt. spec. wires are standard—save industry special engineering, source and delivery problems.

Wire and Cable Div., Ft. Wayne, Ind.



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Prime source for plastic and rubber power supply cords. Terminations of all types (molded plastic and rubber) with infinite design possibilities. Complete line of Coiled Cords including HPN.

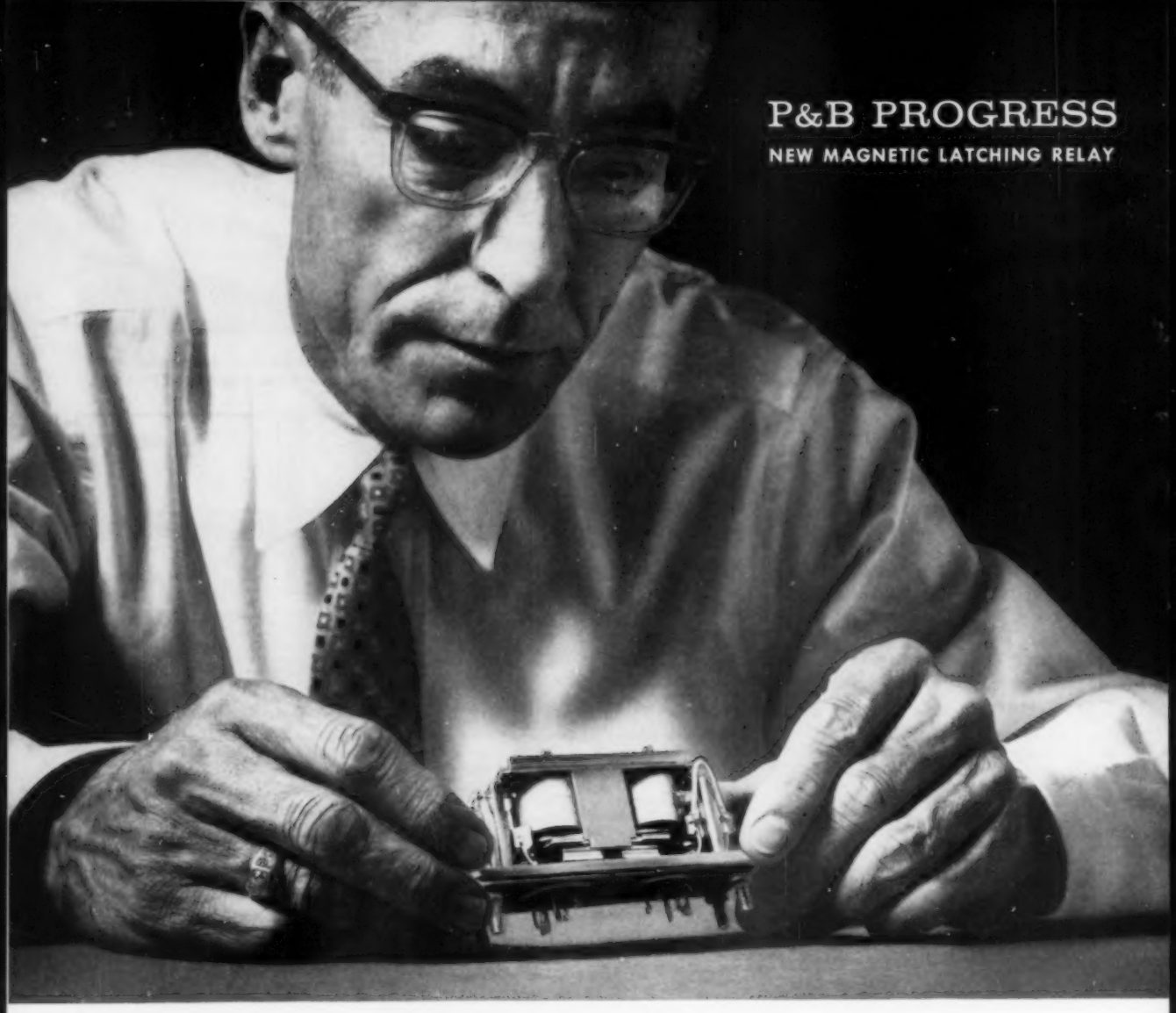
Cords Limited Division, DeKalb, Ill.

TYPE MS RELAY

A low cost, space saving single pole or common multiple contact D.C. unit. Highly reliable. Can be built to withstand extreme environmental conditions.

R-B-M Control Div., Logansport, Ind.

ESSEX WIRE CORPORATION



NEW RELAY SWITCHES 30 AMPS

Withstands 100g Shock* and 30g Vibration, 55 to 2000 cps.

KG11DG is an extra heavy duty DPDT *magnetic latching* relay. Its silver cadmium oxide contacts will carry 30 amperes, and the whole structure will withstand 100g shock*. Vibration resistance is 30g, 55 to 2000 cps. A permanent magnet is employed to (1) lock the armature into position, (2) accelerate armature transfer, and (3) greatly increase shock and vibration resistance. • KG23D is a 6PDT version of this relay with the contacts rated at 3 and 5 amperes. It has the same shock and vibration resistance and operates with exceptional reliability over a range of contact loads from dry circuits to 5 amperes, 28 volts DC, resistive.

**Contact openings of less than 80 microseconds.*

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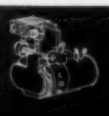
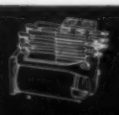
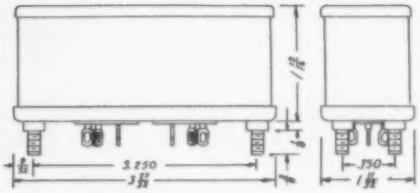
More than 20,000 Variations







KG11DG RELAY		KG23D RELAY
30 AMPS	GENERAL	3 & 5 AMPS
Teflon, Glass & Ceramic.	—Insulation—	Teflon, Glass & Ceramic.
1000 megohms min.	—Insulation Resistance—	1000 megohms min.
1000 volts rms.	—Breakdown Voltage—	1000 volts rms.
100g with less than 80 micro-seconds opening.	—Shock—	100g with less than 80 micro-seconds opening.
30g from 55 to 2000 cps; .195" max. excursion from 10 to 55 cps.	—Vibration—	30g from 55 to 2000 cps; .195" max. excursion from 10 to 55 cps.
—65°C. to +125°C.	—Ambient Temperature—	—65°C. to +125°C.
13 ozs.	—Weight—	13 ozs.
12 ms. with 225 ohm coil @24V DC.	—Pull-in-Speed—	12 ms. with 225 ohm coil @24V DC.
Two 5-pin multiple solder headers. Contacts: Heavy-duty pierced solder terminals. Coils: Hook end for 3 #20 AWG wires.	—Terminals—	Two multiple solder headers with hook ends for 3 #20 AWG wires.
Hermetically sealed only.	—Enclosures—	Hermetically sealed only.
	CONTACTS	
2 Form Z. (DPDT Double make—double break)	—Arrangements—	2, 4, and 6 Form C.
30 amps @28V DC resistive.	—Load—	Dry circuits. 5 amps @28V DC resistive. 3 amps @115V AC resistive.
Silver cadmium oxide.	—Material—	Palladium (Gold-flashed for dry circuits).
	COIL	
2.6 watts approx. at nominal voltage.	—Power—	2.6 watts approx. at nominal voltage.
Either coil may be left energized without damage.	—Duty—	Either coil may be left energized without damage.
Teflon tape and Ceramic.	—Insulation—	Teflon tape and Ceramic.
Four 5/16 inch #8-32 studs on 3¼ x ¾ inch centers.	—Mounting—	Four 5/16 inch #8-32 studs on 3¼ x ¾ inch centers.

Voltage:	6VDC	12VDC	24VDC	48VDC	110VDC
Resistance:	14 ohms	55 ohms	225 ohms	835 ohms	5500 ohms

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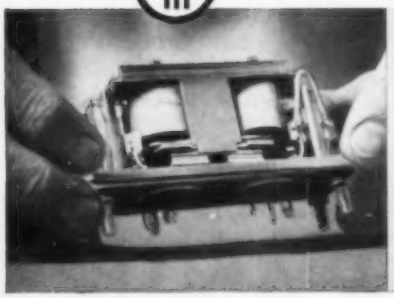

Potter & Brumfield, Inc., Princeton, Indiana
Attn: T. B. White, Brig. Gen. USMC (Ret.)
Special Projects Engineer

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Vapor Deposition of Molybdenum and Niobium on Stainless Steel Tubes

C. F. Powell, *Publication No. BMI-1228, available from Office of Technical Services, US Dept. of Commerce, Washington 25, D. C.*, 7½x11¼. $0.50.

With the quickening of interest in niobium (columbium), and in all the high-temperature metals, projects like the one Battelle Memorial Institute describes here are of increasing interest. This is basic research, though, and much remains to be done before a fully satisfactory—and low cost—coating is developed.

Heat Transfer, Vol. II

Max Jakob. *Published by John Wiley & Sons, New York*, 9¼x6, 652 pp. $15.

The organization of this book follows that of Vol. I. Sections, equations, tables, figures and problems are numbered consecutively through each individual chapter and also identified by chapter number. The table of contents carries the fine subdivisions, expediting the location of a major topic. Location of numerical data is facilitated by the lists of tables and figures on the pages immediately following the table of contents. The author deals mainly with selected fields or heat-transfer applications, but he also of-

(Continued on page 126)

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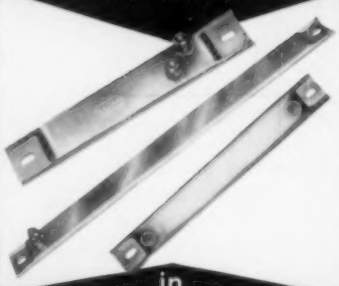

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fers a comprehensive analysis and discussion of heat radiation in spaces of simple configuration.

The presentation of the subject-matter is thorough and its treatment critical. A considerable amount of additional raw material had been set aside by Dr. Jakob at the time of his death. Those supplements that were only partially completed have been finished and added to the work by Peter Kezios, who rendered technical and editorial assistance during publication.

Television Interference, Its Causes and Cures

PHIL RAND. *Published by Nelson Publishing Co., P.O. Box 36, Redding Ridge, Conn., 8½x11, 56 pp. $1.75.*

This book's ten chapters cover fields of interest to design engineers of all products that generate radio frequencies: electronic devices, electrical controls, welding and high frequency heating equipment.

Proceedings of President's Conference on Small Business Research

Published by Office of Technical Services, US Dept. of Commerce, Washington 25, D.C., 297 pp. $2.50.

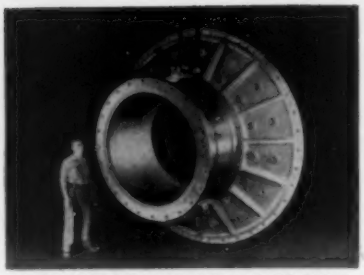
How can small businesses obtain and use the benefits of today's wealth of technical and marketing research to improve their products and increase sales and profits? Answers to this question were suggested at a conference called by President Eisenhower last Sept. 23-25 in Washington, which was attended by 1000 representatives of small and large businesses and the various sources of small business assistance in the technical and distribution fields.

Scientific Societies in the United States

RALPH S. BATES, *Published by Columbia University Press, 2960 Broadway, New York 27, 6x9; 297 pp. $6.50.*

This book describes development of scientific and technological societies and organizations in the US. Their influence on the development of our economy and society is discussed and their inter-relationships described.

(Continued on page 129)



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Write today to Meehanite Metal Corporation, Dept. 7-G, 714 North Avenue, New Rochelle, N. Y.

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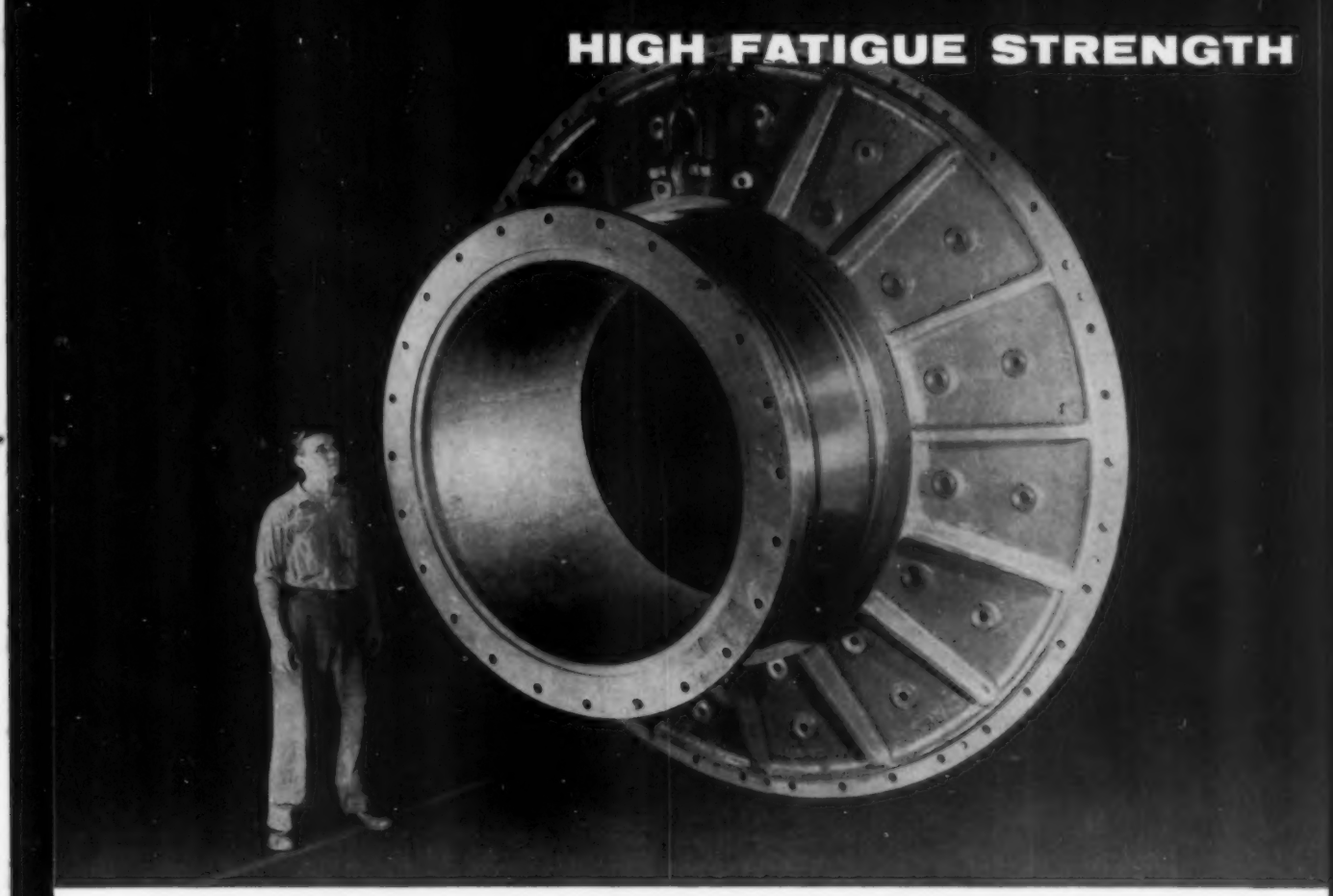

Meehanite castings possess exceptional strength properties and toughness

This one-piece Meehanite casting is the feed end head for 10′ diameter Nordberg Ball and Rod Mills used to reduce hard, abrasive Taconite Iron Ore to the fineness of flour.

In service, each trunnion supports a continuously rotating and shifting load in excess of 200 tons. Though subject to heavy moving stresses day in and day out, Meehanite metal possesses the mechanical properties necessary for long continuous operation

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Meehanite metal finds wide application in the manufacture of many components subject to heavy moving stresses and dynamic loads.

For additional engineering information write for your free casting data sheet: TD-1 "What Is Meehanite."®

Meehanite castings are used extensively in each of the 58 Nordberg Grinding Mills shown installed in an ore concentration plant up in the Iron Range of Minnesota.

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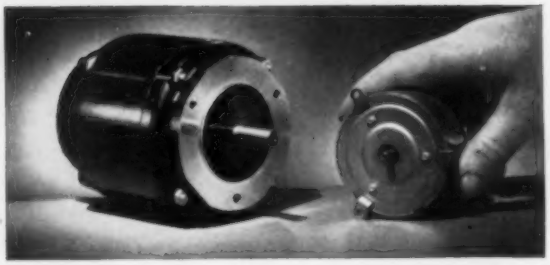
MEEHANITE METAL CORPORATION, NEW ROCHELLE, NEW YORK

GEARLESS, HIGH-TORQUE, REVERSIBLE

75-RPM and 100-RPM SYNCHRONOUS MOTORS



These amazing gearless motors develop up to 75 oz.-in. torque, feature instantaneous acceleration to synchronous speed within ½ cycle, and have extremely high torque for synchronous motors of this size. Can be reversed instantly. These motors—with lubricated-for-life bearings—withstand continuous duty or stalling with only 40C rise.

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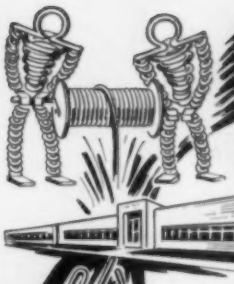

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Basic information about a great many organizations, including many in engineering, is given.

Of particular interest is the chapter, "The Triumph of Specialization, 1866-1918," which describes the social, technological and economic factors that have brought about the great complex of organizations existing throughout the scientific-engineering and industrial fields today. Both a bibliography and an index are provided.

Motion and Time Study

RALPH M. BARNES, *Professor of Engineering and Production Management, U. of California, Los Angeles, Calif. Published by John Wiley & Sons, Inc., 440 Fourth Ave., New York 16. Fourth edition 6x9, 665 pp. $9.25.*

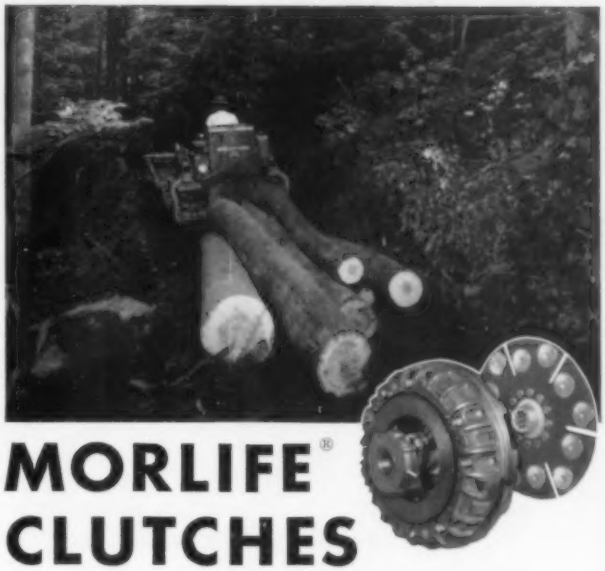
Where manual work is performed there is always the problem of finding the most economical way of doing the task, and then of determining the mount of work that should be done in a given period. This is usually accompanied by some incentive.

The author's purpose is to present the basic principles that underlie the successful application of motion and time study, supplementing each with illustrations and examples.

The book includes new material on developments in the industrial use of pulse rate as an index of physical activity. The section on time study is enlarged by new material on statistical procedures in time study and information on auditing of methods, time standards, and wage-incentive plans. All known systems of motion data are outlined and four of these systems are described in detail, including complete tables of motion-time data.

"Thank heaven, you got here!"

ROCKFORD



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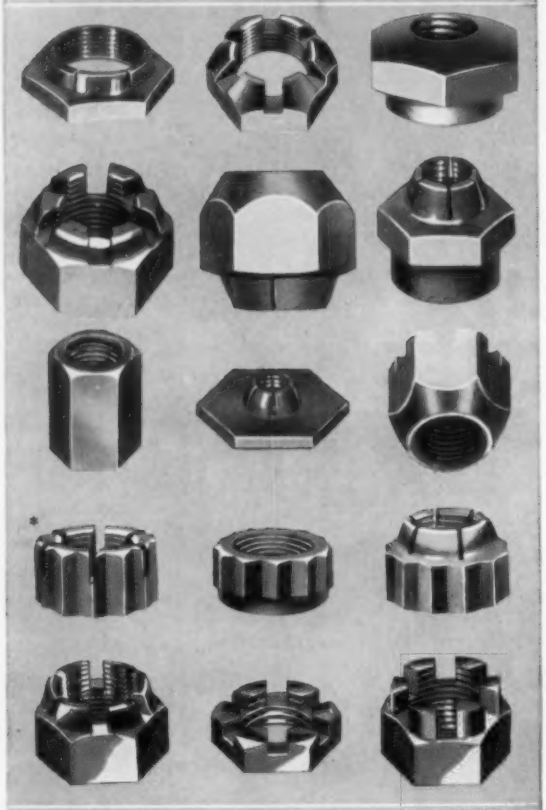

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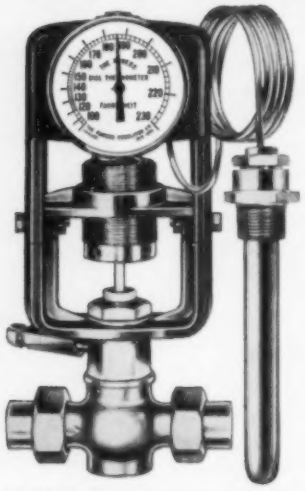

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Selected articles in recent issues have been reprinted in convenient form for filing. As long as the supply lasts, readers in US and Canada can secure one copy of any of these reprints without charge, by using one of the Reader Service Cards bound inside the back cover. Note that the card must be used within 60 days of publication date. If more than one copy is needed, see price list at end of this listing.

While the supply lasts, single copies of the following reprints are obtainable by using the Reader Service Card.

Sandwich-panel Adhesives
The 14 most widely specified adhesives, with comparison table. May 26, '58, p. 56.
Circle No. E 26

Coriolis Acceleration
Describes with equations how this force affects various components. May 26, 58, p. 72. Circle No. E 25

Semiconductor Rectifiers
Comparison of both germanium and silicon as low-cost rectifiers. May 12, '58, p. 89. Circle No. E 24

Midget Batteries
Specialized power packages where current or voltage needs can be kept low. May 12, '58, p. 72. Circle No. E 23

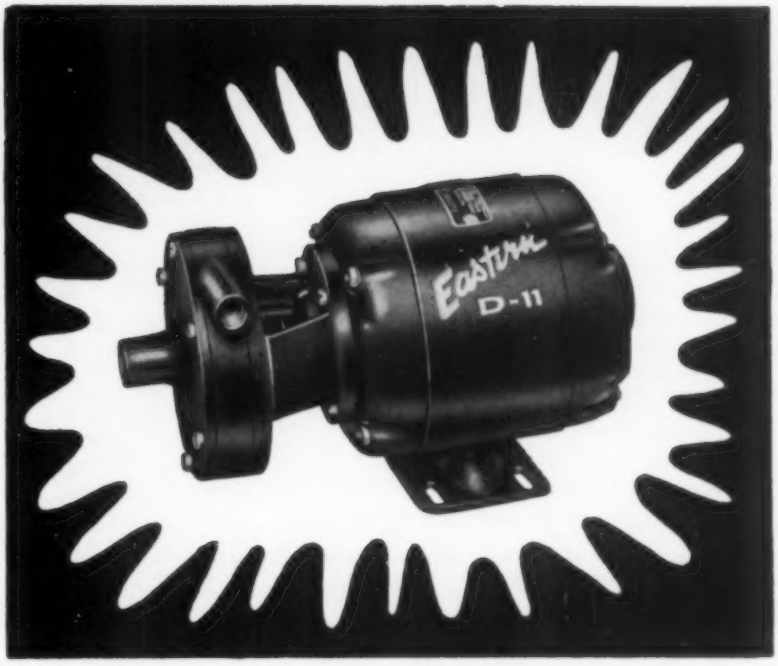
Sandwich-panel Facing Materials
Apr. 28, '58, p. 80. Second of three articles gives data for selecting the skin material. Circle No. E 22

Fan Selection
Apr. 28, '58, p. 92. Three fan laws; charts, tables and sample problems.
Circle No. E 21

Silicone Rubber Parts
Tips on curing methods, shape of parts and material selection for best service. Apr. 14, '58, p. 69). Circle No. E 20

Pressure Drops in Air Valves
Technique estimates pressure losses in a pneumatic system, component by component. Charts give K-factors for actual valves and fittings. Apr. 14, '58, p. 74.
Circle No. E 19

(Continued on page 133)



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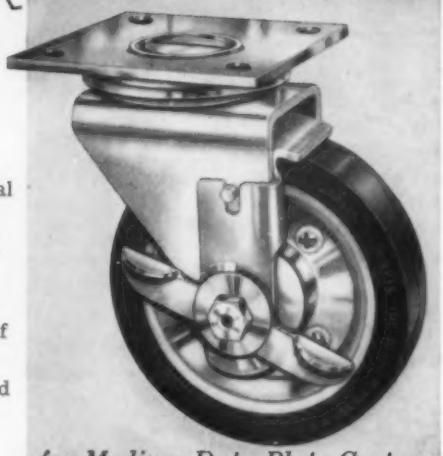

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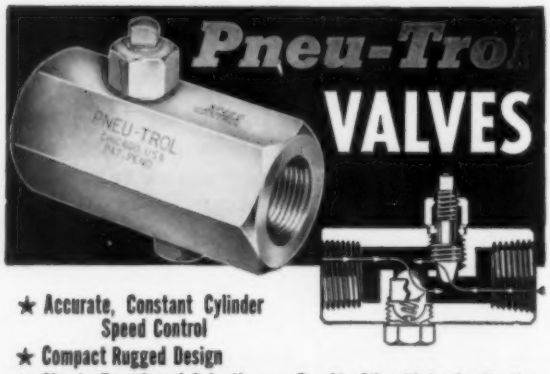

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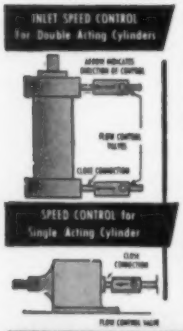

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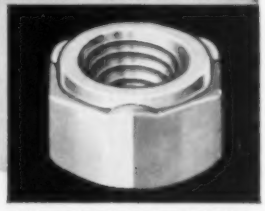

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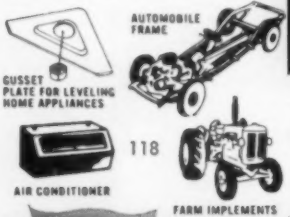

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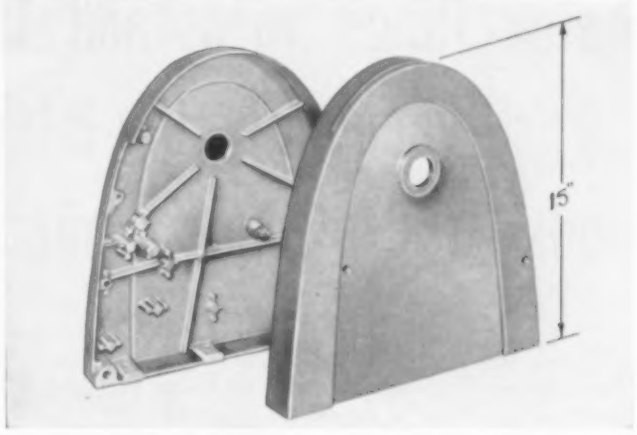

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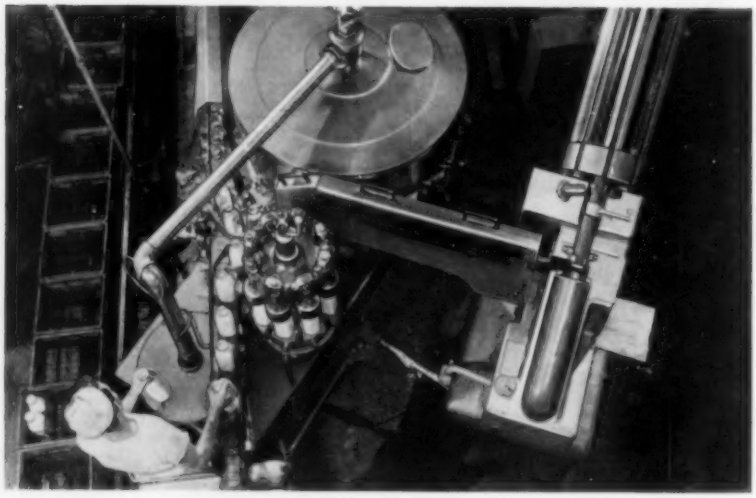

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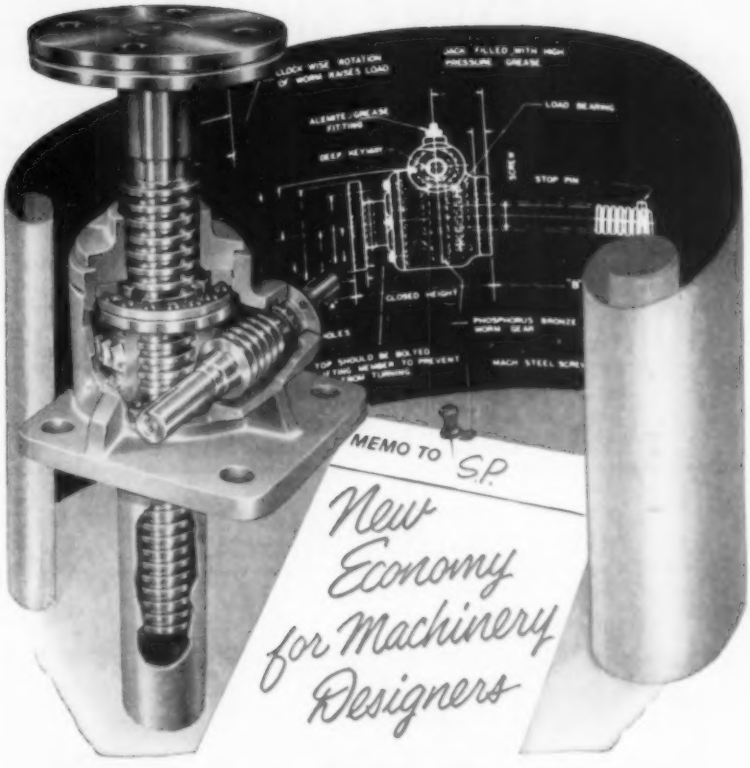

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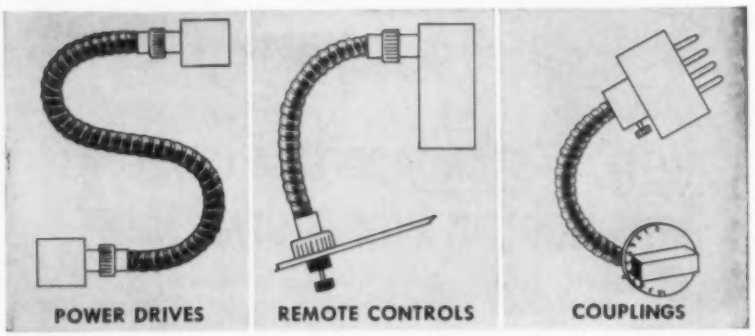

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E14. Which Adhesive for What
Design guide and fast-reference table with application data (3/17/58)

E15. Textured Steel
New processes, texturing methods, design data and trends (3/17/58)

E17. Bearings for 300F and Up
Special materials and lubricants that give better performance for instrument bearings (2/3/58)

E18. Plastics for Abrasion Resistance
Properties tabulated for wear resisting elastometers and rigid plastics (3/31/58)

E19. K Factors
Charts give K-factors, for actual valves and fittings (4/14/58)

E20. Silicone Rubber Parts
Tips on curing methods, shape of parts and other variables that determine satisfactory service. (4/14/58)

E21. Fan Selection
Three fan laws; charts, tables and sample problems (4/28/58)

E22. Sandwich-Panel Facing Materials
Second of three articles gives data for selecting the skin material. (4/28/58)

E23. Midget Batteries
Power package for specialized applications. (5/12/58)

E24. Semiconductor Rectifiers
Comparison of germanium and silicone rectifiers. (5/12/58)

E25. Coriolis Acceleration
Equations show how it affects components. (5/26/58)

E26. Sandwich-panel Adhesives
The 14 most-specified adhesives compared. (5/26/58)

NEW COMPONENTS

DESCRIPTION OF THESE NEW ENGINEERIN

GENERAL ENGINEERING

11—Linear-motion Potentiometer
19—Transistorised Digital Systems
21—Digital Logging Clock
30—Triple-angle Triangle
29—Hand Sighting Level
28—Measures Temperatures

METALS & ALLOYS

7—Aluminum-bronze Alloy
25—Nickel-silicon Copper

NEW CATALOGS

DESCRIBED ON PAGES 117-121

GENERAL ENGINEERING

48—Industrial Pressure Gages, 16 pp., American Machine and Metals, Inc.
57—Reproduction Materials, 12 pp., Eastman Kodak Co.

METALS & ALLOYS

33—Cold Finished Bar Products, 28 pp., Republic Steel Corp.
36—Sealing Alloys, 4 pp., Wilbur B. Driver Co.
50—Sponge Iron Powder, 8 pp., Hoeganaes Sponge Iron Corp.
51—Low-temperature Melting Alloys, 8 pp., Cerro de Pasco Sales Corp.

NON-METALLIC MATERIALS, FINISHES

54—Phosphate Coating for Steel, 4 pp., American Chemical Paint Co.
56—Low-compression Butyl Compound, 4 pp., Precision Rubber Products Corp.
58—SPE Prospectus, 15 pp., Society of Plastics Engineers, Inc.

FABRICATION PROCESSES AND PRODUCTION

31—Impact Extrusion, 28 pp., Phenoll Mfg. Co.

POWER TRANSMISSION

53—Dry Fluid Drives, 2 pp., Dodge Mfg. Corp.

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ITEMS APPEAR ON PAGES 87-112. CIRCLE KEY NUMBER FOR ADDITIONAL INFORMATION.

NON-METALLIC MATERIALS, FINISHES
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13—Welding Dissimilar Metals

POWER TRANSMISSION
1—Clutch Disengages at Preset Position

MECHANICAL PARTS
2—High-temperature Bearing
15—All-steel Hub

FASTENING AND JOINING
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5—Right-angle Swivel Fittings
10—Replaceable Nut Element
22—Larger Head Diameters

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37—Pump and Motor

ELECTRICAL, ELECTRONIC COMPONENTS
6—Rotary Action Solenoid
8—Rotating Cam Limit Switch
14—Key-operated Plug
16—Numbered Indicating Lights
23—Waterproof Hand Switch
17—Foot, Knee, Elbow Switch

HYDRAULIC, PNEUMATIC EQUIPMENT
9—Hydraulic Accumulators
12—Pressure-compensated Valve
18—Miniature Cylinder
20—Miniature Centrifugal Blowers
26—Duplex Pressure Switch

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40—Plastic Knobs, 8 pp., Waterbury Cos., Inc.
38—Miniature Ball Bearings, 6 pp., Barden Corp.
47—Meter Mountings, 4 pp., Lord Mfg. Co.

FASTENING AND JOINING
34—Socket Head Set and Cap Screws, 24 pp., Abbott Screw & Mfg. Co.
46—Couplings, 12 pp., Browning Mfg. Co.

MOTORS, ENGINES AND CONTROLS
44—Motor Selection, 12 pp., Century Electric Co.
55—Motor Protectors, 4 pp., Metals & Controls Corp.

ELECTRICAL, ELECTRONIC COMPONENTS
35—Miniature and Subminiature Relays, 16 pp., Iren Fireman Mfg. Co.
39—Carbon and Graphite Brushes, 12 pp., Speer Carbon Co.
42—Subminiature Teflon Terminals, 8 pp., Trinseal, Inc.
45—Subminiature Switches, 4 pp., W. L. Maxon Corp.
49—Lighted Pushbutton Switches, 8 pp., Micro Switch Co.

HYDRAULIC, PNEUMATIC EQUIPMENT
32—Safety Relief Valves, 44 pp., Farris Engineering Corp.
41—Medium Pressure Hose and Fittings, 8 pp., Parker-Hannifin Corp.
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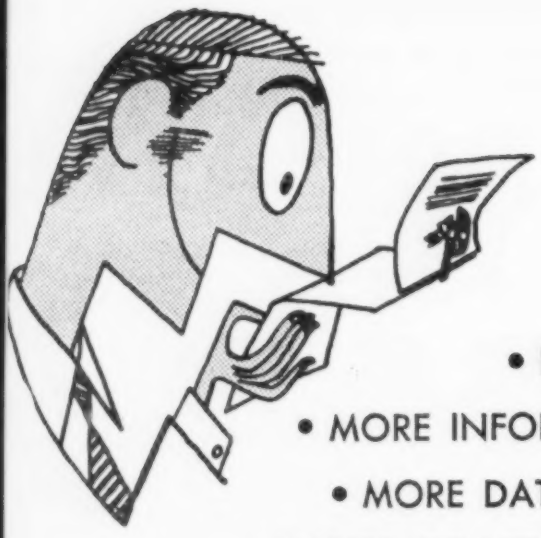

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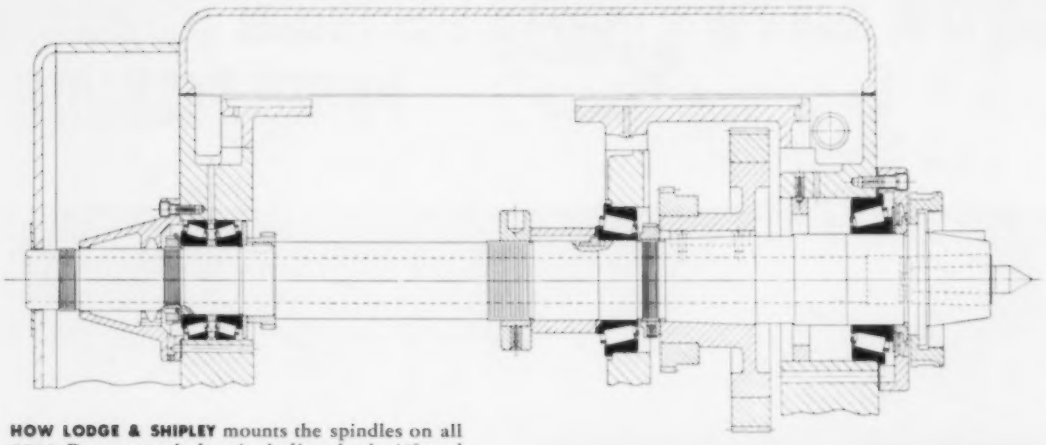

HOW LODGE & SHIPLEY mounts the spindles on all 2013 Powerturn lathes including both 45° and 90° Copymatics on Timken bearings to get extra rigidity, maintain accuracy, reduce maintenance.

New type lathe ups production 200%, saves users an estimated $8,000 a year

...one secret—TIMKEN® bearings on the spindle

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How spindle is held rigid. Timken bearings hold the spindle in positive alignment. They take *both* radial and thrust loads in any combination, because of their tapered design. And because of full line contact between rollers and races, Timken bearings have extra load-carrying capacity.

Why heavy shocks are absorbed. Case-carburization of Timken bearings' rollers and races gives them hard, wear-resistant surfaces and tough, shock-resistant cores.

How friction is virtually eliminated. Timken bearings are geometrically designed to roll true. And they're precision-made to live up to their design. They run smoother—last longer.

We even make our own electric furnace fine alloy steel, for extra quality control. We're America's only bearing maker that does. To get all these advantages, always specify bearings trade-marked "TIMKEN". The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ontario. Cable address: "TIMROSCO".

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